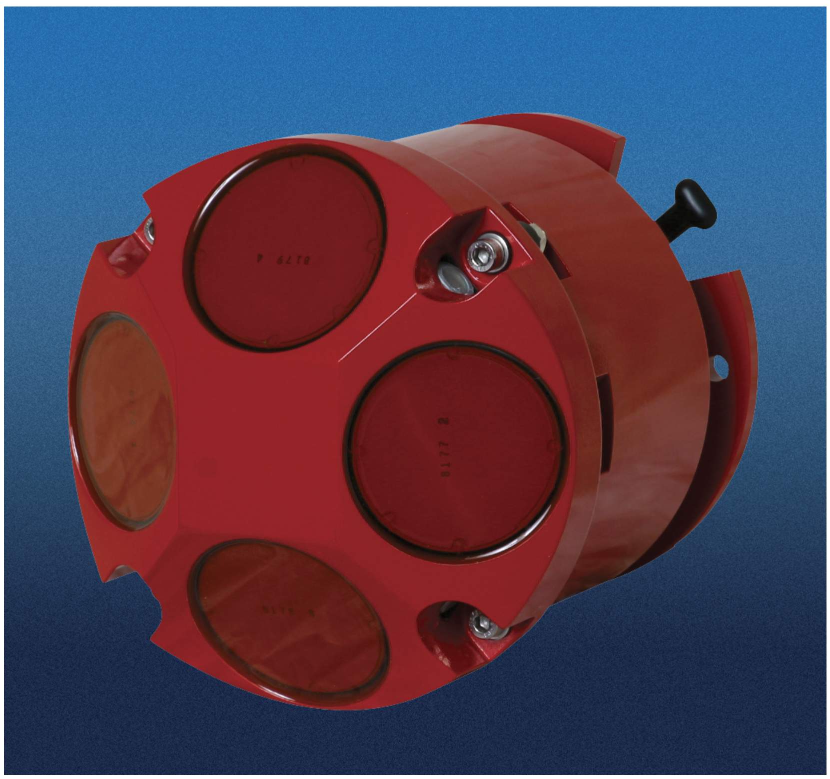
Navigator

Doppler Velocity Log

TECHNICAL MANUAL



P/N 957-6172-00 (November 2006)

TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Table of Contents

List of Figures

List of Tables

Navigator Technical Manual

1 Introduction

Thank you for purchasing a Teledyne RD Instruments (TRDI) Navigator Doppler Velocity Log (DVL). This Technical Manual is designed to help Navigator users to get familiar with their system.

1.1 Getting Started

You are probably eager to get started, but take a moment to read a few words of guidance. We strongly recommend you read *all* of the provided documentation to learn the full capabilities of your Navigator.

The Navigator Technical Manual includes the following sections:

Introduction. This section is an overview of the Navigator system.

Setup. This section contains information on how to setup the Navigator hardware and software.

Installation. Use this section to plan your installation requirements.

Maintenance. This section covers Navigator maintenance. Use this section to make sure the Navigator is ready for a deployment.

Test. Use this section to test the Navigator.

Troubleshooting. This section includes a system overview and how to troubleshoot the Navigator. If the Navigator fails a built-in test or you cannot communicate with the system, use this section to help locate the problem.

Commands and Output Data Format. This section contains a reference for all commands and output data formats used by the Navigator. Use the *Command Quick Reference Card* to help remember the direct commands used by the Navigator.

The Documentation CD includes:

The Documentation CD has Adobe Acrobat® Portable Document File (pdf) versions of all the user documentation. Use the electronic documentation to quickly search for information.

> **NOTE.** When an addition or correction to the manual is needed, an Interim Change Notice (ICN) will be posted to our web site on the Customer Service page (www.rdinstrument.com). Please check our web site often.

1.2 Conventions Used in Manuals

Conventions used in the Navigator Technical Manual have been established to help you learn how to use the Navigator quickly and easily.

Windows menu items are printed in bold: **File** menu, **Collect Data**. Items that need to be typed by the user or keys to press will be shown as **<F1>**. If a key combination were joined with a plus sign (**<ALT+F>**), you would press and hold the first key while you press the second key. Words printed in italics include program names (*BBTalk*) and file names (*default.txt*).

Code or sample files are printed using a fixed font. Here is an example:

```
[Break Wakeup A]
Navigator DVL Version 9.xx
RD Instruments (c) 1996-2005
All rights reserved.
>
```

You will find two other visual aids that help you: Notes and Cautions.

> **NOTE.** This paragraph format indicates additional information that may help you avoid problems or that should be considered in using the described features.

> **CAUTION.** This paragraph format warns the reader of hazardous procedures (for example, activities that may cause loss of data or damage to the Navigator).

1.3 Navigator Options

The following section explains the different options available for Navigator DVLs.

Navigator Options

Water Profiling – The Navigator DVL can be upgraded to perform water current profiling and dredge plume or sediment tracking.

Shallow Water Bottom Track Mode 7 – You can use your 1200KHz Navigator DVL in water as shallow as 30cm (see "FSA-015 - Shallow Water Bottom Tracking Bottom Mode 7," page 333).

High-Resolution Water Profiling Modes – This upgrade allows you to collect water profiles using Water Modes 1, 5, 8, and 11 (see "WM - Profiling Mode," page 211).

High Ping Rate Water Profiling Mode 12 – Use your DVL to profile fast moving shallow water. This upgrade offers increased resolution of up to 1cm and uses multiple sub-pings to improve the standard deviation of each measurement (see "WM - Profiling Mode," page 211).

External Batteries – Use an External Battery with a Navigator DVL to provide backup power or for self-contained deployments.

High-Pressure External Battery case – Use External batteries in a 6000m depth rating Battery Case. See the "Outline Installation Drawings," page 277 for dimensions and weights.

High-Pressure Housing – The standard Navigator housing allows deployment depths to 3000 meters (200 meters for systems purchased prior to December 2004). High-pressure systems are available in depth rating of 6000 meters. See the "Outline Installation Drawings," page 277 for dimensions and weights.

Memory – Navigator DVLs do not include a memory card. Two PCMCIA memory card slots are available, with the total memory capacity not to exceed 2GB (see "PC Card Recorder," page 69).

Spare boards kit – Contains a complete set of spare printed circuit boards for a Navigator DVL. The set does not include the receiver board (not field replaceable).

1.4 Navigator Care

This section contains a list of items you should be aware of every time you handle, use, or deploy your Navigator. *Please refer to this list often*.

1.4.1 General Handling Guidelines

Never set the transducer on a hard or rough surface. **The urethane faces may be damaged.**

Always remove the retaining strap on the underwater-connect cable and dummy plug when disconnecting them. **Failure to do so will break the retainer strap.**

Do not apply any upward force on the end-cap connector as the I/O cable is being disconnected. **Stressing the connector may cause the DVL to flood.** Read the Maintenance section for details on disconnecting the I/O cable.

Do not expose the transducer faces to prolonged sunlight. **The urethane faces may develop cracks.** Cover the transducer faces on the Navigator if it will be exposed to sunlight.

Do not expose the I/O connector to prolonged sunlight. **The plastic may become brittle.** Cover the connector on the Navigator if it will be exposed to sunlight.

Do not store the DVL in temperatures over 60 degrees C with the batteries removed. **The urethane faces may be damaged.** Check the temperature indicator inside the shipping case. It changes color if the temperature limit is exceeded.

Store batteries in a **cool dry location** (0 to 21 degrees C). If the batteries are installed in the external battery case, do not store the battery case in temperatures over 21 degrees C.

Do not store batteries inside the external battery case for extended periods. **The batteries may leak.**

Use batteries within one year. **Batteries stored for more than 12 months should NEVER be used!**

Vent the system before opening by loosing the hardware on the housing. **If the DVL flooded, there may be gas under pressure inside the housing.**

Do not scratch or damage the O-ring surfaces or grooves. **If scratches or damage exists, they may provide a leakage path and cause the DVL to flood.** Do not risk a deployment with damaged O-ring surfaces.

Do not lift or support a Navigator by the external I/O cable. **The connector or cable will break.**

1.4.2 Assembly Guidelines

Read the Maintenance section for details on Navigator re-assembly. Make sure the housing assembly O-ring stays in the groove when you re-assemble the Navigator. Tighten the hardware as specified. **Loose, missing, stripped hardware, or a damaged O-ring can cause the Navigator transducer to flood.**

Place a light amount of silicone lubricant on the connector pins (rubber portion only). **This will make it easier to connect or remove the I/O cable and dummy plug.**

Do not connect or disconnect the I/O cable with power applied. When you connect the cable with power applied, you may see a small spark. **The connector pins may become pitted and worn.**

The **Navigator** I/O cable is *wet* mate-able, <u>not</u> *under water* mate-able.

1.4.3 Deployment Guidelines

Read the Navigator Technical Manual and the Software User's Guides. **These guides have tutorials to help you learn how to use the DVL.**

Align the compass whenever the recorder module is replaced, or when any ferrous metals are relocated inside or around the Navigator housing. **Ferro-magnetic materials affect the compass.**

The AC power adapter is not designed to withstand water. **Use caution when using on decks in wet conditions.**

Avoid using ferro-magnetic materials in the mounting fixtures or near the Navigator. **Ferro-magnetic materials affect the compass.**

1.5 System Overview

The Navigator DVL system consists of a DVL, cables, and software. They only require the addition of a Windows® compatible computer to configure the DVL and replay collected data.

The transducer assembly contains the transducer ceramics and electronics. The standard acoustic frequencies are 300, 600, and 1200 kHz. See the outline drawing for dimensions and weights.

I/O Cable Connector – Input/Output (I/O) cable connects the Navigator DVL to the computer and external power supply.

Forward Mark – The forward mark shows the mounting location of Forward.

Urethane Faces – The urethane faces covers the transducer ceramics. Never set the transducer on a hard surface. The urethane faces may be damaged.

Housing – The standard Navigator housing allows deployment depths to 3000 meters (2000 meters for unit purchased prior to 2004). High pressure housings are also available for deployment depths to 6000m.

Thermistor – The Thermistor measures the water temperature.

Pressure Sensor – The pressure sensor (standard 200 Bar) measures water pressure (depth).

Transducer Head – The Navigator electronics and transducer ceramics are mounted to the transducer head. The numbers embossed on the edge of the transducer indicate the beam number. When assembling the unit, match the transducer beam number 3 with the Beam 3 mark on the end-cap.

End-Cap – The end-cap holds the I/O cable connector. When assembling the unit, match the Beam 3 mark on the end-cap with beam 3 number on the transducer.

Flash Memory Card – Navigator DVLs do not include a memory card. Two PCMCIA memory cards slots are available, with the total memory capacity not to exceed 2GB.

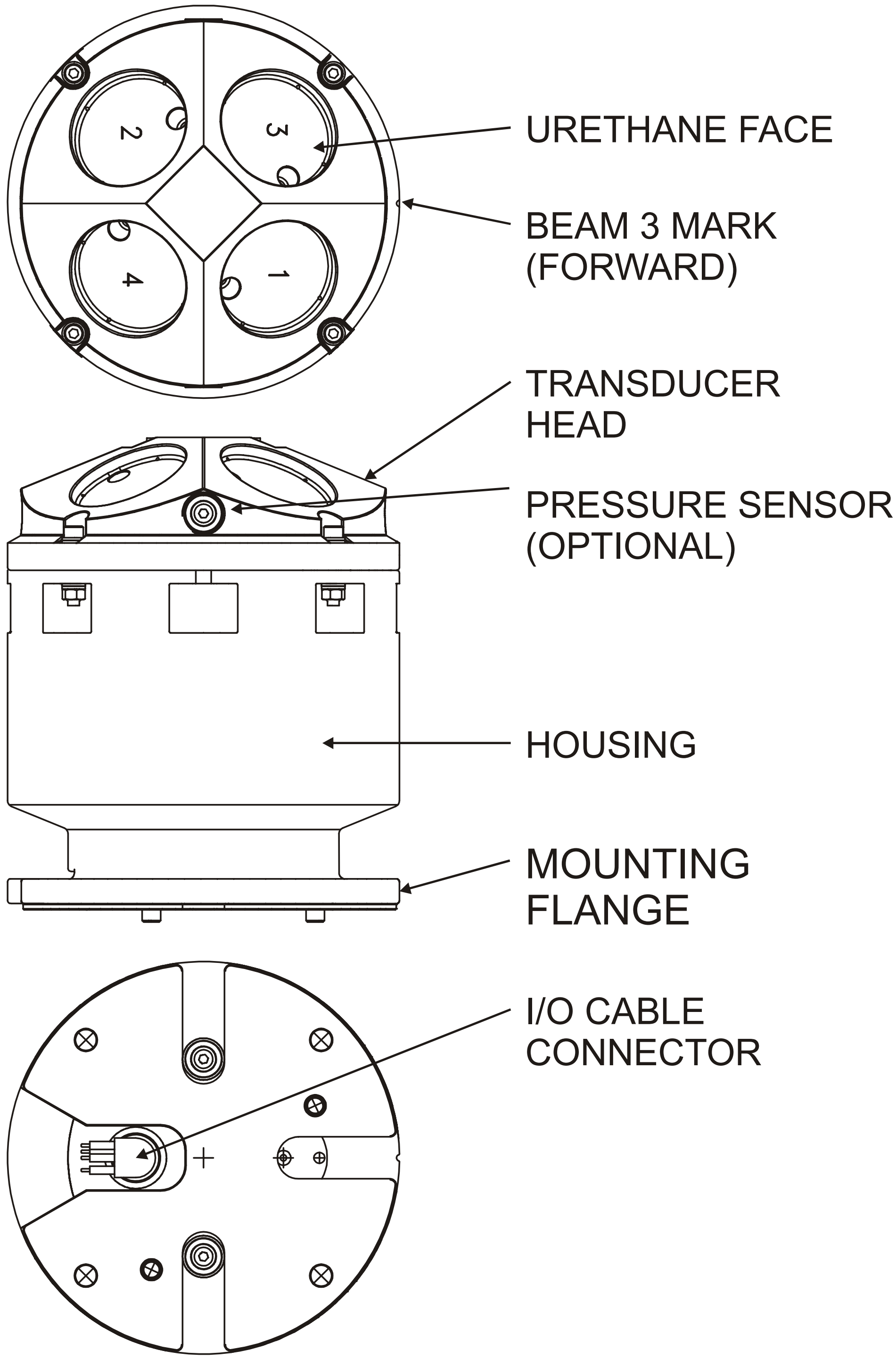


Figure 1. Navigator DVL Overview

1.6 Unpacking

When unpacking, use care to prevent physical damage to the transducer face and connector. Use a soft pad to protect the transducer. When handling any electronics modules, follow electrostatic discharge (ESD) prevention measures.

1.6.1 Inventory

You should have the following items.

DVL transducer

I/O cable

AC power adapter

Ship Kit (includes CD manual, CD software, and power cords)

Shipping case (please save all foam for reshipping use)

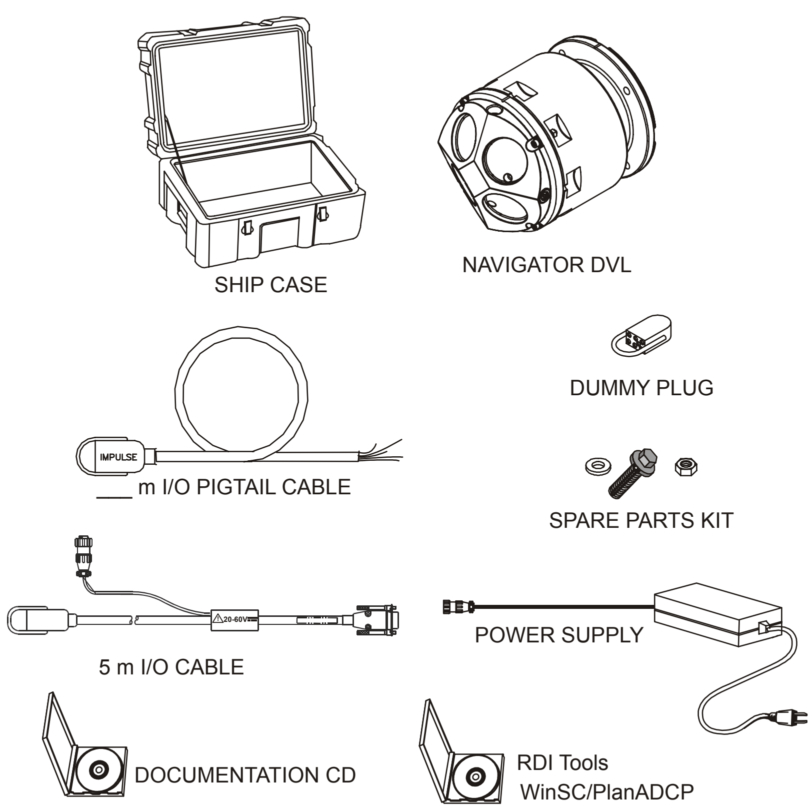


Figure 2. Inventory

1.6.2 Visual Inspection of the Navigator

Inspect the Navigator using the following table and Figure 1, page 7. If you find any discrepancies, call TRDI for instructions.

Table 1: Visual Inspection Criteria

Item	Inspection Criteria
Transducer	Check the urethane face. There should be no gouges, dents, scrapes, or peeling.
I/O connector	Check the I/O connector for cracks or bent pins.
I/O Cable	Check the cable connectors for cracks or bent pins.

2 Software

TRDI has utility programs to help you set up, use, test, and trouble-shoot your Navigator DVL. Each program has a User's Guide and help file that you can print, or you can view help while running the program.

Table 2: Navigator Software Main Modules

Program Name	Description
BBTalk	Windows DVL communication program. Use this program to "talk" to the DVL and to run test script files. *BBTalk* is included on the RDI Tools CD. For detailed information on how to use *BBTalk*, see the *RDI Tools User's Guide* located on the RDI Tools CD.
PlanADCP	*PlanADCP* lets you enter known or "best-guess" values for the various ADCP profiling parameters and shows predictions of expected results. For detailed information on how to use *PlanADCP*, see the *WinSC and PlanADCP* User's Guide located on the WinSC and PlanADCP CD.
WinADCP (optional)	Gives users a visual display of the entire set of data. You can zoom in on a portion of the data for closer analysis and you can export data to text or MatLab files. For detailed information on how to use *WinADCP*, see the *WinADCP User's Guide* located on the WinADCP CD.

NOTE. *WinADCP* is only provided if the Navigator includes the water profiling upgrade.

2.1 System Requirements

The Navigator software requires the following:

- Windows XP® or Windows 2000®
- Pentium III 400 MHz class PC (higher recommended)
- 64 megabytes of RAM (128 MB RAM recommended)
- 10 MB Free Disk Space plus space for data files (A large, fast hard disk is recommended)
- One Serial Port (two or more High Speed UART Serial Port recommended)
- Minimum display resolution of 1024 x 768, 256 color (higher recommended)
- CD-ROM Drive
- Mouse or other pointing device

2.2 Software Installation

To install the Navigator software programs, do the following.

a. Insert the compact disc into your CD-ROM drive and then follow the browser instructions on your screen. If the browser does not appear, complete Steps “b” through “d.”

b. Click the **Start** button, and then click **Run**.

c. Type **<drive>:launch**. For example, if your CD-ROM drive is drive D, type **d:launch**.

d. Follow the browser instructions on your screen

3 Setup the Navigator

Figure 3 illustrates how to connect the Navigator cables and adapters on your workbench. You will need a container of water large enough to submerge the Navigator's transducer head into during testing (two to three inches of water is sufficient). Testing the Navigator out of water may cause some tests to fail but causes no harm to the Navigator.

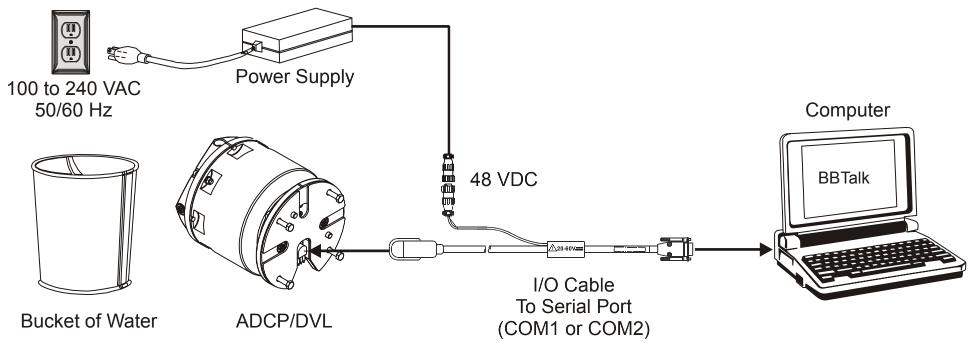


Figure 3. Navigator Connections

3.1 Serial Communication

The standard communications setting for Navigators is RS-232, 9600-baud, no parity, 8 data bits and 1 stop bit. If the serial protocol for the Navigator DVL is set for RS422 and your computer expects RS232, you will need an optional RS232 to RS422 adapter between the Navigator cable and your computer. You can set the Navigator for baud rates other than 9600 baud (see the CB command).

RS422. The WorkHorse Navigator is normally set for RS232, but changing a switch setting on the PIO board can change it to RS422. The switch is in plain view on the top circuit board, near the cable connectors. The settings are marked on the board. This manual assumes that you use RS232.

Use *BBTalk* to communicate with the DVL.

a. Start *BBTalk*.

b. Send a BREAK to the Navigator by pressing the **End** key. When the Navigator receives a BREAK signal, it responds with a wake-up message similar to the one shown below. The Navigator is now ready to accept commands at the ">" prompt.

```
[Break Wakeup A]
Navigator DVL Version 9.xx
RD Instruments (c) 1996-2005
All rights reserved.
>
```

If your Navigator does not respond, check the serial port, cables, and power. If necessary, refer to "Troubleshooting," page 90.

4 Installation

This section is a *guide* for installing the Navigator DVL on either ROVs, AUVs, ASVs, Towfish, or vessels. Use this section to plan your installation layout. You can also use this information to see what requirements you must consider before purchasing a DVL. We recommend you distribute this information to your organization's decision-makers and installation engineers.

We are not experts in installing the Navigator aboard a ship. There are too many installation methods. We suggest you seek expert advice in this area because of its importance in DVL performance. However, we can give you guidelines based on theory and on how others have installed their systems. In return, we do appreciate receiving information about your installation and the results.

CAUTION. Always use caution when mounting the Navigator. Never rest the transducer head on a rough surface. Use foam padding to protect the transducer during handling.

4.1 Over-the-Side Mounting

The over-the-side mount is common if you want the ability to move the Navigator from one ship to another. You must make the mount as rigid as possible to limit the amount of pitch and roll applied to the DVL. Although the tilt sensor can measure a ±20° influence, anything beyond 15° will cause bias to the data that cannot be removed. No matter what mounting type used, the DVL must be below the bubble layer. Bubbles will cling to the urethane faces of the DVL and reduce the range to almost nothing. Usually a mount somewhere aft of amidship is used. A stern mount will cause all sorts of problems due to propeller wake, bubbles, and turbulent water conditions.

NOTE. Avoid using ferro-magnetic materials in the mounting fixtures or near the DVL. They affect the compass. Use 304 stainless steel for fresh water and 316 stainless steel for salt-water applications.

4.1.1 Floating Objects

Over the side assembly is sturdy, but we did not design it to withstand collisions with all floating objects. We strongly suggest you use the in-hull mount (see "In-Vehicle Mounting," page 14) if this is a possibility.

4.1.2 Example of an Over-the-Side Mount

When mounting the DVL Over-the-Side, use the following sequence.

Test the DVL

Align the compass

Mount the DVL Over-the-Side (see Figure 4).

1. Hand winch with cable or rope.
2. Boat cleat to tie off the lower end of the channel.
3. Aluminum channel, 5" base x 2" high x 3/16" thick. You need to determine how long the channel needs to be as the drawing is not to any scale. The channel should be notched for the end-cap flange of the Housing Assembly. This will give the system a positive lock after the DVL has been strapped to the channel.
4. Pivot housing - This could be a very heavy one-piece bent housing, or a three-piece assembly. Bolt the pivot housing to the deck of the boat (or buoy).
5. Nylon strap clamps - Two clamps are needed. Place some rubber or foam between the housing and the aluminum channel before clamping to protect the DVL.

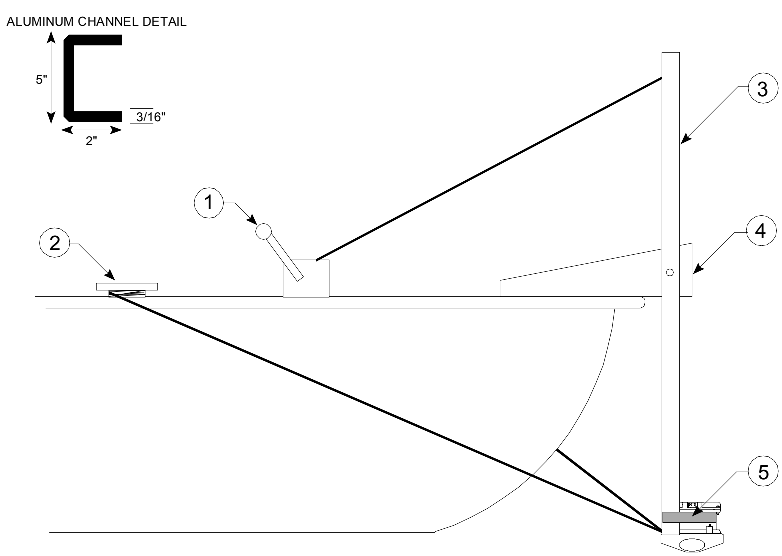


Figure 4. Over-the-Side Mounting of a DVL

4.1.3 Over-the-Side Mounting Special Considerations

Use the following suggestions when mounting the DVL over-the-side of a vessel or more broadly to a vessel.

It is desirable to rigidly mount the DVL to the vessel or over-the-side fixture. You want to avoid the free spinning of the DVL in this application. The DVL must stay in the water at all times.

The DVL must be mounted deep enough so that turbulence caused by its movement through the water does not allow air bubbles to be attached to the transducer faces.

Avoid mounting the DVL near motors and thrusters. They cause air bubbles and will cause bias to the internal compass.

Avoid mountings that will cause the DVL to see severe accelerations.

4.2 In-Vehicle Mounting

The In-Vehicle mounted DVL is common when it is intended to keep the system on a single vessel (AUV, ASV, ROV, towfish, etc.) or when over-the-side mounting is not practical for your vessel. For this type of mounting, there are several issues such as beam clearance and access that must be addressed. In this section we propose guidelines for In-Vehicle mounting of the DVL.

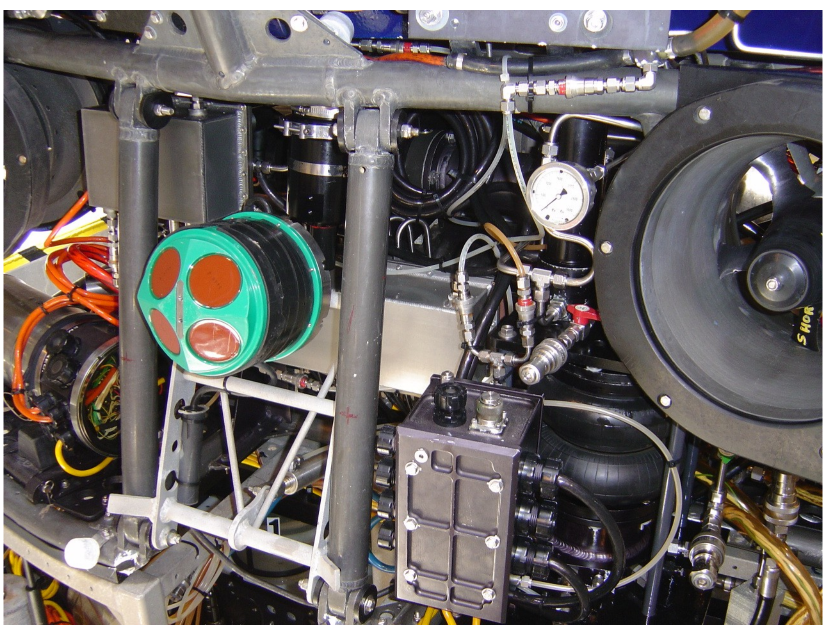


Figure 5. Example of a Navigator Mounted on a ROV

You must consider several potential problems before installing the transducer head assembly. Read this section before deciding where to install the transducer assembly. See the outline installation drawings for specifications on our standard DVL transducer heads (see "Outline Installation Drawings," page 277).

4.2.1 Location

Ideally, you want to install the transducer head:

Where it is accessible both internally (for access to transducer electronics) and externally (to remove biofouling).

Away from shipboard protrusions that reflect DVL energy. Allow for a reflection-free clearance of 15° around each beam (see the "Outline Installation Drawings," page 277 and "FSA-019 - ADCP Beam Clearance Area," page 340).

Away from other acoustic/sonar devices, especially those operating at the same frequency (or harmonic) of the DVL (see "FSA-018 - Triggering a DVL with a TTL Signal," page 337).

Close to the ship's fore-to-aft centerline. As distance from the centerline increases, vertical accelerations caused by the roll of the ship also increase. These accelerations can cause additional uncertainties in DVL velocity measurements.

As far away as possible from thrusters and motors.

If mounting to a ROV that tends to kick up sediment, mount the DVL as far forward as possible.

Other considerations may be:

Ease of installation.

Portability (wanting to move the instrument from vessel to vessel).

Permanent installation.

With all of these choices come their respective advantages and disadvantages. We will show in this chapter several options for installation and then in the next chapter we will go through respective general concerns that you may have to deal with once you install or mount the Navigator DVL in a vehicle.

4.2.2 Sea Chest In-Hull Mounting

A sea chest (Figure 6, page 16) is a fixture that surrounds and holds the transducer head, protecting it from debris in the water. The bottom of the sea chest must be open to seawater to allow the acoustic beams to pass through freely. For Sea Chest design and installation consideration see "Application Note 7 - Conceptual Design of a Sea Chest," page 288.

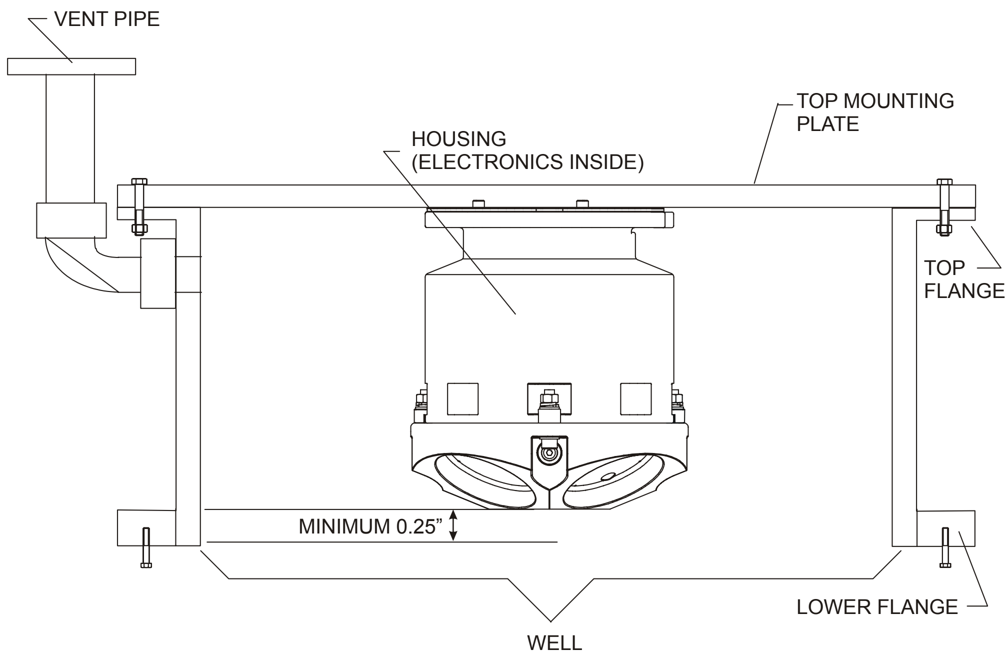


Figure 6. Sea Chest Mounted Transducer

4.2.3 Fairing

A fairing is a structure that produces a smooth outline and reduces drag or water resistance. The fairing also diverts floating objects away from the transducer. A fairing that is shaped like a teardrop, sloped such that the leading edge (closer to the bow) is higher than the back edge, and extends below the hull (typically 12 inches) will divert the air bubbles away from the transducer faces.

4.2.4 Acoustic Window

While we do not fully understand windows, we do believe that windows can be used to produce overall performance improvements in vessel-mounted DVLs. Additionally, if the ship operates where there is danger of barnacle damage or a high density of ice or other floating objects, then the use of an acoustic window is the only option.

It is theoretically possible to use a window successfully; however there are several advantages and disadvantages to consider before using an acoustic window.

Advantages

- Well will not fill with air bubbles caused by the ship moving through the surface water, see "Sea Chest In-Hull Mounting," page 15
- Flow noise is reduced, see "Flow Noise," page 21.

- The well can be filled with fresh water to limit corrosion.
- Barnacles can not grow on the transducer faces. Barnacle growth is the number one cause of failure of the transducer beams.
- The transducer is protected from debris floating in the water.

Disadvantages

- The range of the DVL will be reduced because the window can and will absorb some of the transmit and receive energy.
- The transmit signal could be reflected into the well, causing the well to "ring" like a bell. This will cause the data being collected during the ringing to be biased. Some ships have reported a loss in range as great as 50 meters. The ringing may be damped by applying sound absorbing material on the well walls (standard neoprene wet suit material has been found to work well), see "Ringing," page 22.
- The transmit signal could be reflected off the window and back into the other beams.

Our experience has allowed us to put together some minimum specific recommendations:

Window orientation. The acoustic window should be flat and parallel to the transducer mounting plate. Note this is not an absolute requirement. However, if the water temperatures inside the window and outside the window are not the same, all four beams will be refracted and actual velocity components will be rotated into a new coordinate system. In particular, some of the horizontal velocity will appear as a vertical velocity.

Window material. Important acoustic properties of the window include acoustic refractive index (which should be as close as possible to that of water), insertion loss (which should be as small as possible) and speed of sound. There are two acoustic refractive indices: one for shear waves and one for plane waves. The acoustic refractive indices are simply the ratios of speed of sound in water to speed of sounds in the material. Insertion loss combines absorption and reflection of sound, and it depends on both the thickness and the material properties of the window. In particular, you should avoid using window thickness equal to odd multiples of shear mode quarter-waves (Dubbelday and Rittenmeyer, 1987; Dubbleday, 1986). Refer to Selfridge (1985) and Thompson (1990) for more information. Note that the speeds of sound in plastics decrease with increasing temperature and that causes the resonant frequencies to shift. This can be a large effect. Neither Selfridge nor Thompson has much information on the temperature coefficients of sound speeds.

Our experience has shown that Polycarbonate windows are very good for the Navigators. The thickness of the materials depends on the frequency you intend to use. Table 3 will help to choose the maximum thickness you should use.

> **NOTE.** One concern with window selection is that it be able to support the weight of the water inside the well once the ship is dry-docked. TRDI recommends that you always fill/drain the well at the same time that you are either filling/draining the dry dock area.

Table 3: Window Thickness

Frequency	Thickness
300	0.5 inches
600	0.25 inches
1200	0.25 inches

Spacing between window and transducer. The primary geometrical factor in design of windows is the reflection of a beam into another beam, causing crosstalk between the beams. The distance of the transducer from the window should be at least 0.25 to 0.5 inches. If installed farther than 0.25 to 0.5 inches, then be sure your window aperture is large enough to clear the convex beams.

The optimum distance for the bottom of the transducer assembly from the window is 0.25 inches ±0.125 inches. Never allow the transducer to touch the window. The farther away the transducer is from the window, the more the sound is reflected off of one beam and then reflected into another beam.

Example

One of our representatives uses a 0.25-inch thick window. He then drills two 30mm holes in the window along the edges. The inside walls are painted with anti-fouling paint. This allows the water to be full of anti-foulant during the time the ship is docked, which is when the barnacle growth occurs. The holes allow the water to exchange when the ship is in motion and allows for draining when the ship is dry-docked (a 0.25” window will not support the weight of the water). He has never had a failure with the window, and has seen only a minimal loss in range (5-30 meters).

It is best if the window is parallel to the bottom edge of the DVL transducer. If the window is at an angle to the DVL transducer bottom edge, it will change the absorption. We do not have experience with different angles, but we have had customers use domes or have the window follow the contour of the ship bottom without noticeable degradation of the data.

Acoustically-absorbing sea chest liner. A sound absorbing material should be used inside the sea chest to minimize the effects of sound ringing within the sea chest. The material should be a minimum of one wavelength thick (include the sound speed of the absorbing material when calculating the size of a wavelength).

As a recall: $\lambda m = Cm/FDVL$, Where Cm = Speed of Sound in the material

FDVL= Center Frequency of your DVL unit

λm= wavelength of the signal in the material

Approximate wavelengths of sound in seawater are given below in Table 4. Using standard neoprene wet suit material has been found to work well with 300 and 600hKz frequency DVLs.

Table 4: Wavelength of sound in seawater (1500 m/s sound speed)

FREQUENCY (kHz)	WAVELENGTH (mm)
300	5
600	2.5
1200	1.25

Fluid in the sea chest. The sea chest should be filled with fresh water. Seawater can be used, but at the cost of increased corrosion. Seawater should not be circulated through the sea chest unless the sea chest has been painted with anti-fouling paint. The pressure within the sea chest should be adjusted to keep the window from bowing in and out, and thereafter, the volume should be kept constant.

4.3 General Mounting Considerations

Now that we have shown you the main methods of mounting the DVL, you must be aware of issues that may cause reduction in range, biased data, fouling, and other performance related considerations.

The DVL should be mounted from the end cap or by a clamp around the body. The mounting surface should be electrically isolated from the DVL (i.e. with rubber between the touching surfaces). This is to ensure that the sacrificial anode works on the DVL and not the clamps. There are four bolt holes on the 300/600 kHz end-cap/housing assembly that can be used for mounting.

4.3.1 Orientation

We recommend you mount the transducer head with Beam 3 rotated to a ship-relative angle of 45° (see “Alignment Procedures (Overview),” page 34 and Figure 13, page 34). This causes the magnitude of the signal in each beam to be about the same. This improves error rejection, reduces the effect of ringing (see “Acoustic Isolation,” page 23), and increases the DVL’s effective velocity range by a factor of 1.4. If you align Beam 3 at an angle other than zero, you must nullify this offset. You can do this using the EA command (see "EA - Heading Alignment," page 164).

Use the ship's roll and pitch reference to mount the transducer head as level as possible. If the head is not level, depth cell (bin) mapping will be incorrect. Large misalignments can cause large velocity measurement errors.

4.3.2 Beam Clearance

Special care should be observed in clearing the DVL beams of any acoustic obstacles. Indeed, a 15 degree clearance cone should be respected around each beam to account for each beam spreading as depicted in Figure 7.

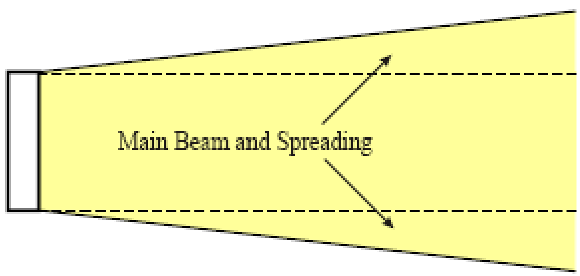


Figure 7. Main Beam and Spreading

Any acoustic obstacle in the Main Beam and Spreading will interfere with the DVL measurement. DVL transducer have sidelobes which could collect energy backscattered by acoustic obstacles in the 15º clearance cone as depicted in Figure 8:

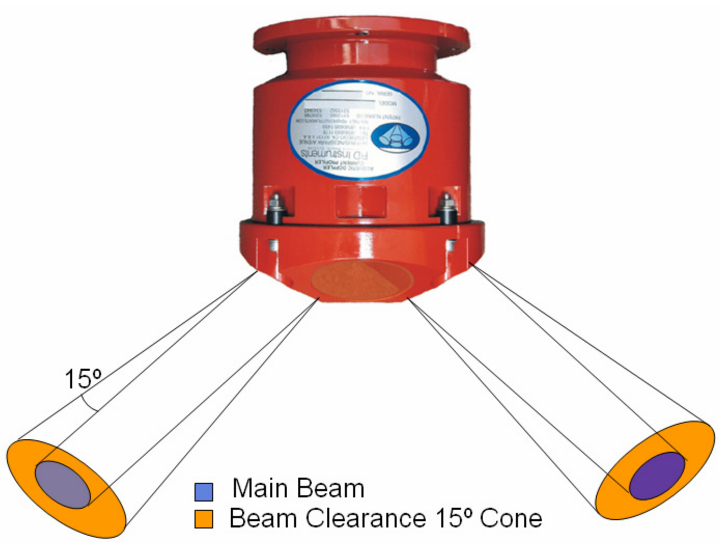


Figure 8. DVL Main Beam and Clearance 15º Cone

Acoustic obstacles are numerous on vehicles: cables, hull, other instruments, etc. These strong backscatters should be cleared from the regions indicated above. This Beam clearance should be observed when Bottom Tracking, Water Tracking and Water Profiling(see “FSA-019 - ADCP Beam Clearance Area,” page 340 for instructions when Water tracking or Profiling).

4.3.3 Air Bubbles

Design your installation to minimize the volume of air bubbles in the path of the acoustic beams. Air bubbles attenuate (weaken) the signal strength and reduce the DVL profiling range. Ships with a deep draft or a non-flat bottom have fewer problems with bubbles. Ways to reduce bubble flow vary with ship characteristics, but two options are available. Mount the transducers below or away from the bubble layer.

The flow layer is usually within the first two feet below the hull. Bubbles can get trapped in this layer. Mounting the transducer head amidship on the fore-to-aft centerline may help. For ships with propulsion systems that make large amounts of bubbles, use a mounting technique that lets you lower the transducer head below the hull while underway.

NOTE. If you use locally made or existing extension hardware instead of the hardware available from TRDI, you may need to make an adapter plate to connect your hardware to our transducer head. Please call us for the exact dimensions and layout of our transducer head bolt holes for your system.

Divert the bubble layer so it flows around the transducers - You can use fairings to alter the bubble flow. An acoustic window (see “Acoustic Window,” page 16) may help reduce the bubble problem, but can cause ringing (see “Acoustic Isolation,” page 23) and attenuation problems.

4.3.4 Flow Noise

Water flowing over the transducer faces increases the acoustic noise level, which decreases the profiling range of the DVL. You can reduce the flow across the transducer faces with a sea chest, fairing, or acoustic window.

4.3.5 Corrosion and Cathodic Disbondment

Your DVL is made of naval bronze, aluminum, or other materials. Standard anode protection used for the ship is installed outside of the well of the transducer head (see Figure 1, page 7). Mounting of the ship’s standard anode protection outside of the transducer well will typically protect the parts that may corrode. However, you should plan regular inspections of the mounting hardware for signs of corrosion. TRDI disposes many corroded hardware sets during inspections. By returning your system for a Refurbishment Service at signs of important corrosion, we can inspect it and replace questionable parts. At the same time, we will inspect the urethane and make any necessary upgrades to boards, assemblies, and firmware. If the Refurbishment Service is not needed, we can upgrade your system as part of one of our Inspection Services. With proper care, general maintenance, and this refurbishment service, you will ensure that your DVL lasts for a minimum of 10 years with no loss in performance.

NOTE. Corrosion can be further reduced if the well is covered with a window and then filled with fresh water.

4.3.6 Ringing

The DVL transmits an acoustic pulse into the water. The main lobe of this pulse bounces off particles in the water and the signals returned from these particles are used to calculate the velocity of the water.

As stated, the main lobe of the transmitted pulse is what we are using to process and calculate a velocity. The transmitted pulse, however, is made up of many side lobes off the main lobe. These side lobes will come in contact with metal of the transducer beam itself and other items in either the water or the well.

The energy from the side lobes will excite the metal of the transducer and anything bolted to the transducer. This causes the transducer and anything attached to it to resonate at the system's transmit frequency. We refer to this as "ringing."

If the DVL is in its receive mode while the transducer is ringing, then it will receive both the return signals from the water and the "ringing." Both of these signals are then processed by the DVL. The ringing causes bias to the velocity data.

All DVLs "ring" for some amount of time. Therefore, each DVL requires a blanking period (time of no data processing) to keep from processing the ringing energy. Each DVL frequency has a different typical ringing duration. The typical ringing period for each DVL frequency is as follows;

Table 5: Ringing Period

Frequency	Ringing Period
300 kHz	2 meters
600 kHz	1.5 meters
1200 kHz	0.8 meters

These typical ringing values are recommended as the minimum setting for all DVLs using default setups.

It should be noted, on some installations the effects of ringing will last longer than the recommended settings above. For example, the effects of ringing will last longer if the transmit signal becomes trapped inside the transducer well. This can occur because the well itself is ringing with the transducer or when windows covering the opening of the well reflect the signal back inside the well.

The window causes the transmit signal to reflect back into the well due to the difference in impedance between the window and the water. When the transmit signal is reflected in the well it becomes trapped and this results in longer ringing periods. To keep from processing this signal, the blanking period would have to be increased. This is possible for Water Profile (see "WF – Blank after Transmit," page 205) but not for Bottom Track.

Line the inside walls of the well with a sound absorbing material to damp the ringing effect. Using standard neoprene wet suit material has been found to work well.

4.3.7 Acoustic Isolation

Try to minimize the acoustic coupling between the transducer head and the ship. Without adequate acoustic isolation, the transducer output will "ring" throughout the ship and feeds back into the DVL receive circuits. Ringing causes bias errors in water-track velocities (See "BK - Water-Mass Layer Mode," page 143 and "BL - Water-Mass Layer Parameters ," page 143 for setting-up water-track/water layer reference on your DVL) and results in the loss of data when water-tracking the closest to the DVL or water profiling in the closest depth cells (bins). Reflections inside a sea chest with an acoustic window also can cause ringing.

You can attain acoustic isolation several ways. At a minimum, use gaskets to isolate all contact points between the ship and the transducer head. Design your installation for:

- A minimum number of contact points between the transducer head and the ship.
- Minimal contact area.
- Single points of contact for positioning and support (when possible).

You also should try to separate the transducer head from the ship using intermediate connections. This is because direct connections transfer the most acoustic energy. Texas A & M used the following installation technique and had minimal ringing problems.

- Transducer mounted to a thin steel plate

Steel plate positioned with three pins set into mounting holes on the hull; pins isolated with gaskets

Steel plate held in place with four I-beams welded to a frame

Frame bolted to another frame and separated by gaskets

Second frame bolted to the ship and separated by gaskets

Acoustic isolation from other acoustic devices on the ship is also necessary. You can do this using the following techniques.

Mount the other acoustic devices as far apart as possible.

Make sure neither the main lobes nor the side lobes of the acoustic devices point at the transducers, including acoustic reflections.

Try not to operate devices that use the same frequency or a harmonic of the DVL's frequency.

4.3.8 Interference

Interference from other acoustic devices can cause velocity and direction bias. In extreme cases it can prevent the DVL from operating. However, it is possible to avoid interference. From our experience, if the other device operating frequency is within 25% of the operating frequency of the DVL or is an odd multiple of the DVL center frequency (e.g. DVL is 307,200Hz, then a third harmonic (multiple) of another device would be 100,000Hz) you may want to prevent both devices from transmitting at the same time (see "FSA-018 - Triggering a DVL with a TTL Signal," page 337).

The DVL transmits a pulse or series of pulses that contain four carrier cycles, i.e. 4T on Figure 9, page 25.

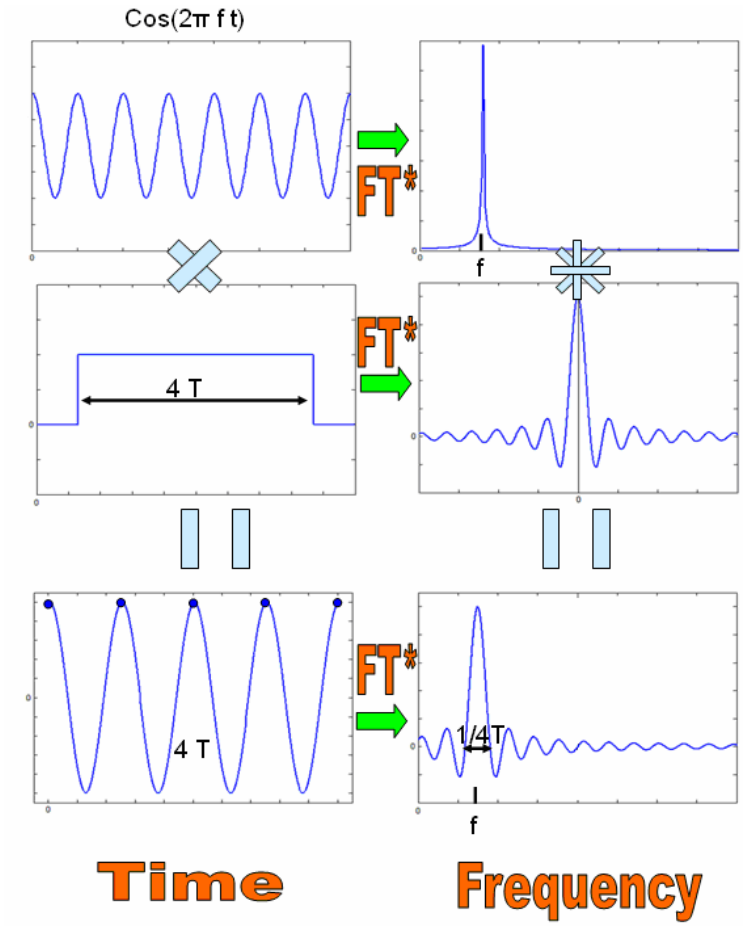


Figure 9. DVL Carrier Cycles

NOTE. * FT = Fourier Transform – used to look at the frequency constant of a signal.

As depicted in Figure 9, an acoustic wave is sent into the water by exciting the transducers with a electric sinusoidal signal, cos(2πft) – (Figure 9 - top left corner). Its Fourier Transform is a Dirac function centered on f the frequency of the sinusoidal signal (Figure 9 - top right corner). Since four carrier cycles constitute the acoustic pulse sent into the water, the sinusoidal signal will have to be truncated. In fact this truncation is equivalent to multiply the sinusoidal signal by a standard rectangular window four carrier cycles wide (cf - middle row left). Its Fourier Transform is a sinus cardinal, i.e. sinc $(\chi) = \sin(\chi) / \chi$ (Figure 9 - middle row right). The result of this multiplication in the time domain is a sinusoidal signal containing four carrier cycles, in other words one pulse (Figure 9 - bottom left corner). Multiplying in time means convolution in the frequency domain. In this case, the sinus cardinal will simply be shifted to be centered on f, the frequency of the sinusoidal signal which is the carrier wave (Figure 9 -

bottom right corner). The resulting transmit frequency bandwidth is 25% of the carrier frequency, i.e. 1/4T=f/4=f.25%. Finally, the front end receive bandwidth is determined by the transducer, and is 40% about the carrier frequency.

The following table summarizes the transmit and receive bandwidth for each frequency available for DVL systems:

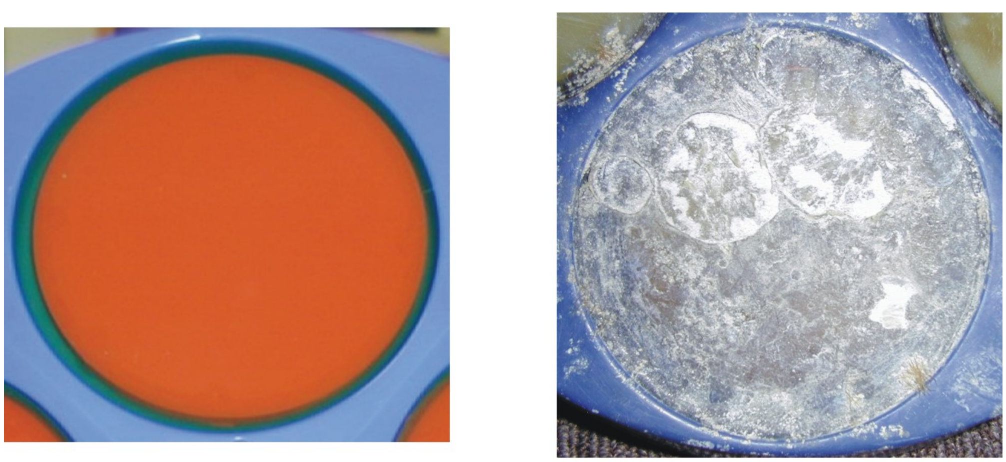
Table 6: Transmit and Receive Bandwidth

System	Carrier frequency	Xmit BW (25%)	Receive BW (~40%)
150kHz	153600Hz	38kHz	58kHz
300kHz	307200Hz	77kHz	103kHz
600kHz	614400Hz	154kHz	206kHz
1200kHz	1228800Hz	307kHz	413kHz

4.3.9 Maintenance

The Maintenance section explains routine maintenance procedures. You rarely need access to the electronics inside the transducer head. However, one external maintenance item is important enough to mention here as it may affect how you install the transducer head.

Objects deployed within about 100 meters (328 feet) of the surface are subject to the buildup of organic sea life (biofouling). This means WorkHorse Navigators are subject to biofouling. Soft-bodied organisms usually cause no problems, but hard barnacle shells can cut through the urethane transducer face causing transducer failure and leakage into the DVL (see Figure 10).



BEFORE AFTER

Figure 10. Barnacle Damage to Urethane Face

The best-known way to control biofouling is cleaning the DVL transducer faces often. However, in many cases this is not possible. The other alternatives include the use of a window or some sort of anti-foulant protection.

Some of our users have had success applying a thin coat (≈4 mm; ≈0.16 in.) of either a 50:50 mix of chili powder and Vaseline or chili powder and silicone grease to the transducer faces. The chili powder should be the hottest that can be found. Water flowing across the transducers will wash this mix away over time. The silicone mixture tends to last longer.

Some organizations may decide to use antifouling grease. However, most antifouling greases are toxic and may cause problems. Recent tests suggest antifouling grease may cause the urethane on the transducer faces to develop cracks. Warmer temperatures accelerate this effect.

The other method is to use antifoulant paint. At present, we recommend the following antifouling paint manufacturer and paint brand: Courtalds Finishes Interlux brand paints, US Telephone: 908-686-1300, Web Page: www.interlux.com.

CAUTION.

1. Read the Material Safety Data Sheet before using any of the listed solvents and paints.
2. Some antifouling coatings may not be legal for use in all areas. Check with your local environmental agency before using the antifouling paint.
3. Do not arbitrarily use antifouling paints. Be aware that antifouling paints can accelerate the dezincification corrosion of brass. Once initiated, dezincificatioin will rapidly destroy the brass.
4. TRDI no longer recommends the use of Nopcocide for the prevention of biofouling. If using antifouling grease, remove it immediately after recovering the DVL.
5. Antifouling grease is toxic. Read the product safety data sheet before using the grease. Wear gloves and a face shield when applying the grease. If the skin comes in contact with the grease, immediately wash the affected area with warm, soapy water.
6. When possible, do not coat the transducer faces with cuprous oxide or related paints that contain chemicals such as copper, chrome, or arsenic. These paints advance the corrosion of the transducer assembly and will cause the urethane to separate from the transducer cups.
7. All US Coastal States prohibit the use of tributyl-tins on boat hulls. The European Economic Commission prohibits the use of many organo-tins. We strongly recommend you obey your local laws.

4.4 Cabling Considerations

Use care when routing the Input/Output (I/O) cable through bulkheads, deck plates, cable runs, and watertight spaces. Make allowances in cable length and engineering design plans for cable routing. When necessary, use strain reliefs on the cable.

The Navigator is shipped with a pigtail I/O cable. The I/O cable connects the transducer head to the computer. The transducer-end connector is molded on, so you can use it below the waterline. Determine what communication setting you will be using and the connector type required (not supplied by TRDI) and wire the pigtail cable as shown in Figure 11. The cable is custom-made in lengths specified by the user. Route this cable so:

It does not have kinks or sharp bends.

You can easily replace it if it fails.

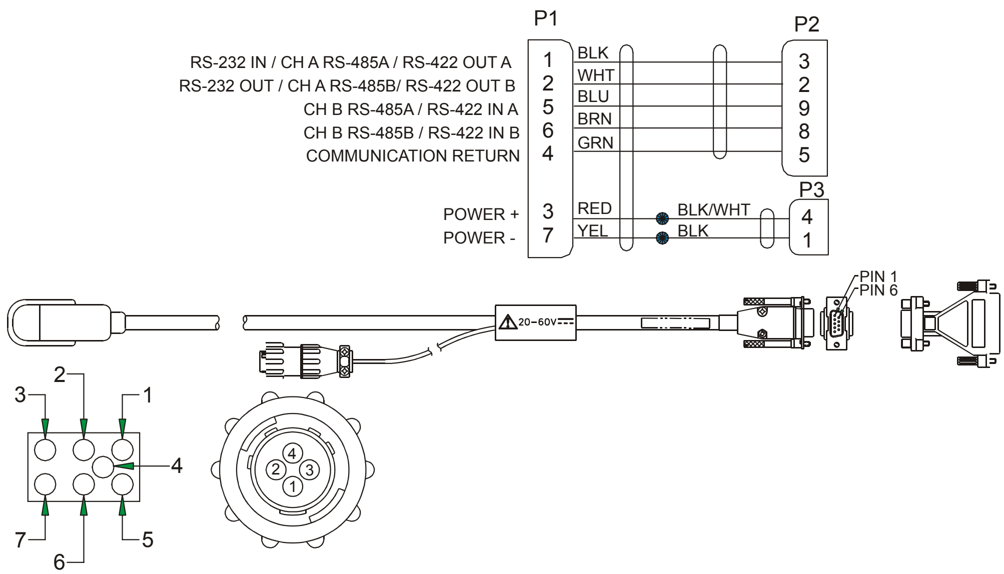


Figure 11. I/O Cable Wiring

> **NOTE.** Color code is shown for reference only. Your cable may be different.

The I/O end-cap connector part number is LPMBH-7-MP from Impulse. The connector on the cable has to be an LPMIL-7-FS. It has 7 pins: two power lines, five for RS422, or three RS232 and two RS485.

4.5 Computer Considerations

We designed the Navigator DVL to use a Windows® compatible computer. The computer controls the DVL and displays its data, usually through our *BBTalk* program. Table 7 lists the minimum computer requirements.

Table 7: Minimum Computer Hardware Requirements

Windows 95®, Windows 98®, Windows NT 4.0® with Service Pack 4 installed, Windows 2000®, or Windows XP®
Pentium class PC 233 MHz (350 MHz or higher recommended)
32 megabytes of RAM (64 MB RAM recommended)
6 MB Free Disk Space (20 MB recommended)
One Serial Port (two or more High Speed UART Serial Port recommended)
Minimum display resolution of 800 x 600, 256 color (1280 x 760 High Color recommended)
CD-ROM Drive
Mouse or other pointing device

4.6 Navigation Interface Considerations

VmDas can read in, decode, and record ensembles from a DVL and NMEA data from some specific (i.e. GPS and attitude sensors) external devices. *VmDas* stores this data in both raw data files (leaving all original data input in its original format) and in a combined, averaged data file. *VmDas* uses all of this data to create different displays for the user.

VmDas looks for, and utilizes the following strings if transmitted: standard GGA (position), HDG/HDT (Heading), VTG (speed and track) messages, and a proprietary PRDID (pitch and roll) message.

As well as being able to input NMEA strings to *VmDas*, it can produce NMEA output strings of speed log information. The speed log contains VDVBW (ground/water speed) and VDDBT (depth).

NOTE. For more information about NMEA data, see "FSA-017 - Using NMEA Heading Strings," page 334 and the *VmDas* and *WinRiver* User's Guides.

4.7 Power Considerations

The AC power adapter provided by TRDI is designed for testing where AC power is available. It provides up to 30 watts at 48 VDC. For deployments, the Navigator requires a power supply designed to supply between 20 to 50 VDC, 25 watts. Navigator power requirements are discussed below.

Sonar performance depends on supply voltage, but not very strongly. The processing electronics use a DC/DC converter, so their function is independent of the supply voltage over the 20 to 50 volt range. However, the raw supply voltage is provided directly to the transmitter so that the transmitted acoustic power is proportional to V_{in}^2. Table 8 shows the bottom-track range (assuming a salinity of 35 ppt and temperature of 5° C) versus supply voltage:

Table 8: Input Voltage vs. Bottom-Track Range for a DVL

Power Supply Voltage (VDC)	Bottom-Track Range (meters)		
	1200kHz	600kHz	300kHz
20	22	83	212
24	23	86	220
30	24	89	228
40	25	92	239
50	26	94	246

Many customers have successfully operated the Navigator using 24 volts. It may be worth the cost of providing a higher supply voltage to achieve the maximum bottom-tracking range.

NOTE. Transmitted power increases or decreases depending on the input voltage. Higher voltage to the DVL (within the voltage range of 20 to 50 VDC) will increase the transmitted power. The transmitted power is increased 6 DB if you double the input voltage from 24 VDC to 48 VDC. For a 300kHz Navigator, each additional DB will result in an increase in range of one default depth cell.

4.7.1 Power Consumption

The average power drawn by a Navigator pinging at its maximum rate at maximum altitude is 3 Watts for a 1200 kHz, 5 Watts for a 600 kHz and 16 Watts for a 300 kHz. This is based on an input voltage of 32 volts. There is a constant background power consumption of 2.2 watts for the processing electronics as long as the Navigator does not “go to sleep.”

The average power consumption depends upon the transmit duty cycle which is a function of many factors. For a Navigator pinging at its maximum rate, the maximum duty cycle is about 13%. By reducing the ping rate, the duty cycle is reduced and therefore overall power consumption may be reduced.

The Navigator contains a capacitor that provides filtering of the high power consumption during transmit. This means that the Navigator should not be adversely affected by reasonable variations in the power supply voltage. It also means that the Navigator should not unduly affect the power supply circuit.

4.7.2 Current Limiting

Peak current drawn by the Navigator is never more than 3 amps due to a current limiting circuit that is provided to prevent blowing a 3 amp internal fuse. At start up this translates to 96 Watts at 32V input.

Note that the power supply must be able to provide at least 10 volts continuously at a current draw of 0.4 amps to get the processor started.

4.7.3 Choosing a Power Supply

There are two keys to choosing a power supply for the Navigator:

Including loss in the wiring, the power supply must be able to supply more then 13 Volts to the Navigator's input connector if the there is 0.15 amp being drawn by the Navigator. This is the minimum voltage needed to start the Navigator.

Should the supply current limit *it must not turn it's output completely off.* The power supply should maintain current flow into the Navigator ("fold back", not "hiccup"). If the supply turns off to protect itself, it will cause the Navigator's internal discharge circuit to discharge the internal capacitors and the Navigator will not start.

> ⚠ **CAUTION.** When using an external DC power supply, set the power supply to the proper voltage BEFORE connecting it to the Navigator, and then turn the power supply OFF when connecting it to the Navigator. Do NOT exceed the rated voltage or equipment damage may occur.

4.7.4 Optional External Battery Pack

The optional External Battery Pack (see Figure 12, page 32) holds two 450 watt-hours batteries.

> ⚠ **CAUTION.** To avoid affecting the compass, place the external battery case at least 30-cm away from the Navigator.

Because many deployments will use only a fraction of the capacity of a single battery pack, you may wish to reuse your battery packs. Use *PlanADCP* to determine the approximate power consumption of your deployment. With experience, you should be able to reuse batteries successfully, but keep in mind the following:

Standard Navigator battery packs hold 28 'D-cell' alkaline batteries with a voltage, when new, of approximately 42 VDC.

When the capacity of a battery pack is 50% used, the voltage (measured across the battery connector under no-load conditions) falls to approximately 32-35 volts. However, keep in mind that this voltage is not an accurate predictor of remaining capacity.

Batteries should be replaced when the voltage falls below 30 VDC (measured across the battery connector under no-load conditions).

Battery packs differ from one to another.

Store batteries in a cool dry location (0 to 21 degrees C).

Do not store batteries inside the external battery case for extended periods. The batteries may leak.

Use batteries within one year (shelf life).

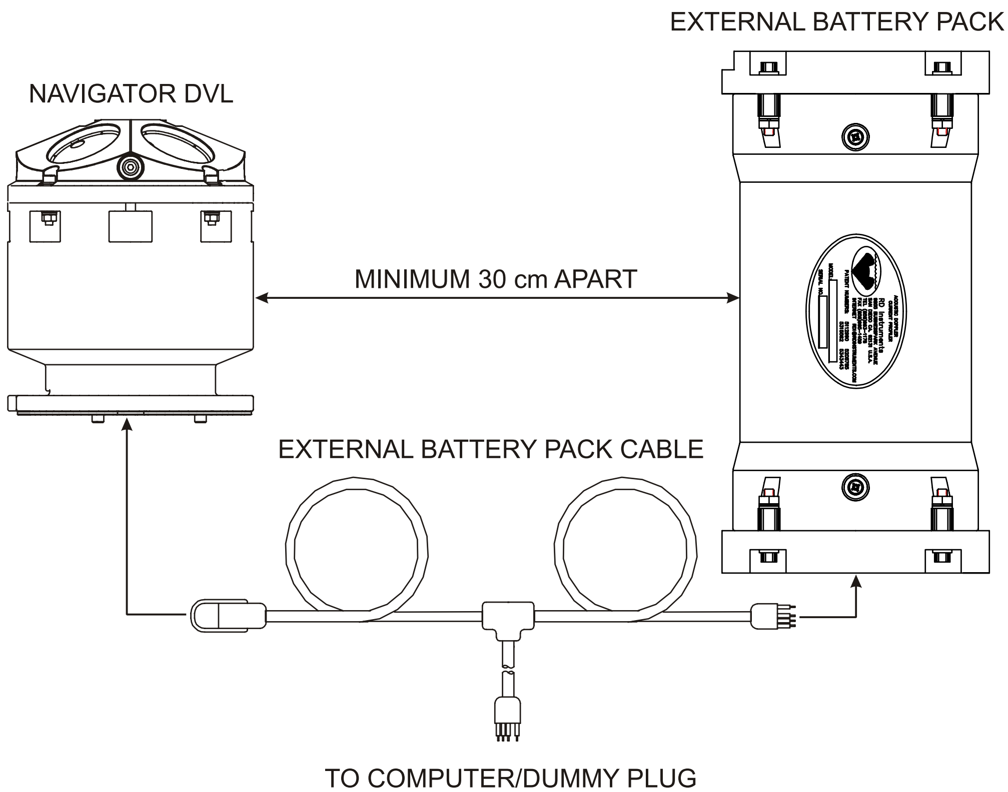


Figure 12. External Battery Pack Connection

If both the optional External Battery Pack and power supply are connected, the Navigator will select the *highest* voltage source for use. The External Battery Pack (when fresh) supply +42 VDC and the AC power adapter output is +48 VDC.

NOTE. The AC Adapter input voltage is sufficient to override the optional external battery voltage (i.e. the ADCP will draw all power from the AC adapter even if the battery is installed and connected).

4.8 Installation Procedures (Overview)

Read these steps before doing them. In general, follow them in the order listed. Some may differ for your installation, so modify them as necessary. Some can be done simultaneously (e.g., hardware installation and software loading). If you have problems or questions, call us (see "Technical Support," page 107).

a. On receipt of the system, read the Navigator Technical Manual.

b. Before installing the system, test the transducer right out of the shipping container. Do the following.

   1. All power to the system DISCONNECTED.

   2. Review "Power Considerations," page 29.

   3. Connect the I/O cable from the computer to the DVL.

   4. Connect the power cable to the I/O cable connector and apply power to the system (Figure 3, page 11 shows all cable connections needed for testing).

   5. Follow testing procedures in "Testing the Navigator," page 85. Test the system. If errors occur, use "Troubleshooting," page 90.

c. Prepare the system for shipboard installation. Disconnect all power to the system. Disconnect all interface cables.

d. Review "Installation," page 12. Install the transducer head. Mechanically align the system (see "Alignment Procedures (Overview)," page 34).

e. Review "Computer Considerations," page 29. Install the computer.

f. Review "Cabling Considerations," page 28. As necessary, route and connect the I/O cable.

g. As necessary, load the software on the computer's hard drive. See "Software," page 9 for help on using the software.

h. Do the Sea Acceptance testing (see "Sea Acceptance Tests," page 88). The Sea Acceptance tests include a Bottom-track (range, accuracy) check.

4.9 Alignment Procedures (Overview)

The mechanical alignment of the transducer head is important to DVL data accuracy. Mechanically mount the head as close as possible to your reference point. This is usually with the Beam 3 mark at 0° or 45° relative to the ship's fore-to-aft centerline. You also must mount the transducer head as level as possible using the ship's roll and pitch references. Review the "Installation," page 12 section for alignment considerations.

When the Navigator is aboard a vessel, the mechanical alignment of the transducer head (Beam 3 mark) is usually aligned with the ship's fore-to-aft centerline (0°), or rotated 45° clockwise. To conceptually determine the misalignment angle, visually hold the DVL still and turn the ship gyro's north reference to match the DVL's north reference. For example, if the Beam 3 mark is pointing at the bow (Figure 13), the misalignment angle is zero.

If the Beam 3 mark is pointing 45° to starboard (Figure 13), you must turn the ship a +45° to align the two north reference points. Conversely, if the Beam 3 mark is pointing 45° to port, you must turn the ship a -45° to align the two reference points (see "EA - Heading Alignment," page 164).

NOTE. We recommend you mount the Navigator with Beam 3 rotated to a ship-relative angle of 45°. This causes the magnitude of the signal in each beam to be about the same. This improves error rejection, reduces the effect of *ringing*, and increases the Navigator's effective velocity range by a factor of 1.4.

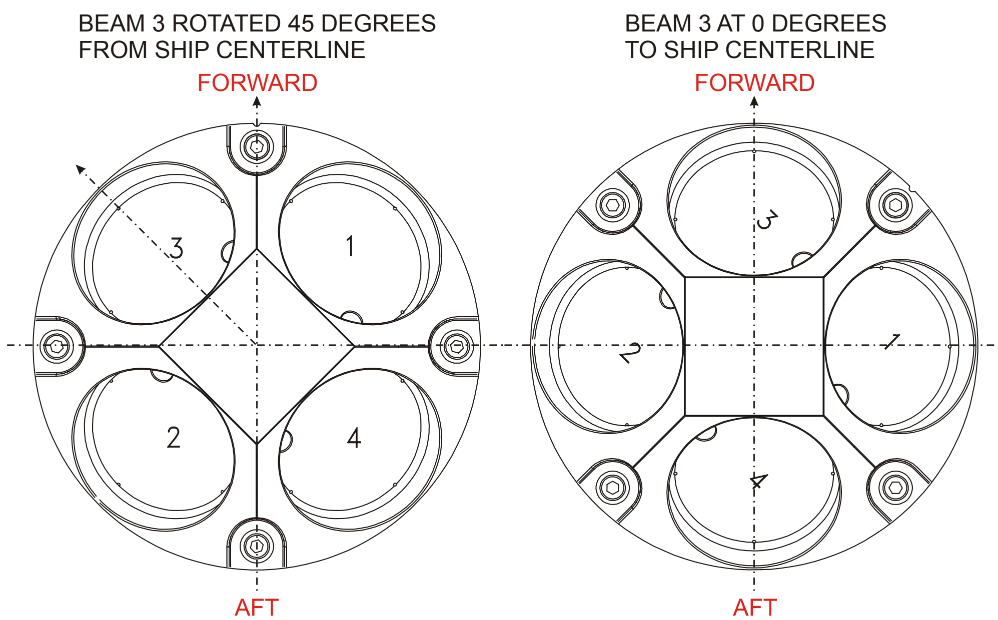


Figure 13. Transducer Misalignment Reference Points

4.10 Frequently Asked Questions

4.10.1 Frequently Asked Mechanical Installation Questions

How do I mount the DVL on my vehicle and where?

The DVL should be mounted from the end cap or by a clamp around the body. The mounting surface should be electrically isolated from the DVL (i.e. with rubber or other insulating material between the touching surfaces). This is to ensure that the sacrificial anode works on the DVL and not the clamps. You should mount the DVL as far from any thrusters and motors as possible. The DVL should be mounted in a position that allows a clear path for all the beams, plus a 15° conical ‘keep out zone’ around each beam because reflections from any solid object located in this cone can interfere with the DVL measurements (see “Installation,” page 12 for further details). The DVL has four beams at 90º azimuth and 30º from the vertical. Typical mountings place it at or near the bottom of the vehicle with the transducer beams pointing downward. This location might be reconsidered for ROVs getting very close to the bottom as generally the thrusters will lift silts which stays in suspension and interfere with the DVL measurement.

How do I align the DVL to my vehicle?

The DVL may be mounted with any azimuth orientation of the beams. The most common choices are:

Beam three pointed forward of the vehicle so that its altitude data may be used for obstacle avoidance.

Beam three rotated to 45° from forward so that all four beams are measuring both along ship and athwartship velocity for increased accuracy.

Teledyne RD Instruments provides an optional alignment jig to help properly align the transducers. The EA command should be used to correct for any rotation angle of beam 3 relative to the vehicle axes (see “EA - Heading Alignment,” page 164). Also see “Frequently Asked Electrical Installation Questions,” page 36 and read the section on alignment (see “Alignment Procedures (Overview),” page 34).

What connector is used on the Navigator?

The I/O connector is LPMBH-7-MP from Impulse. The connector on the cable has to be an LPMIL-7-FS. It has 7 pins: two power lines, five for RS422, or three RS232 and two RS485 (RS communication pins are shared, see “Navigator Cables,” page 108).

What is the depth rating for my DVL?

The standard unit is currently rated to 3000m with a standard option for 6000m. Other non-standard depth ratings are available on request. If you already have a DVL and are uncertain as to its depth rating, please refer to the system configuration sheet that was shipped with the DVL.

How is the DVL protected against corrosion and erosion?

We typically hard anodize and then paint our standard DVLs. Sacrificial anodes are fitted to the DVL to prevent corrosion (see "Zinc Anode Inspection and Replacement," page 71). As for water ingress, our units are sealed with O-rings for operation at pressure. A desiccant bag is put inside the unit to remove any internal residual moisture or humidity.

What are the considerations when installing an acoustic window?

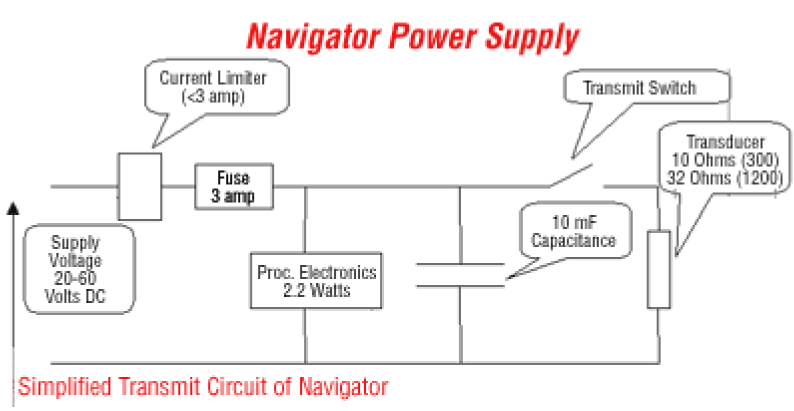
We supply a detailed information to cover this subject (see "Acoustic Window," page 16 and "FSA-010 - Using Acoustic Windows," page 301).

What is the weight of the Navigator DVL?

Material	Frequency	Weight in Air	Weight in Water	Working Depth
Titanium	300/600	44.2 lbs / 20.1kg	30lbs /13.6kg	6000m
	1200	39.6 lbs / 18kg	26.6 lbs / 12.1kg	6000m
Alum. 6061	300/600	34.7 lbs / 15.8kg	19.4 lbs / 8.8kg	3000m
	1200	27.3 lbs / 12.4kg	13.4 lbs / 6.1kg	3000m

4.10.2 Frequently Asked Electrical Installation Questions

How much power do I need?



Navigator Power Supply Requirements

The manual suggests that a 50-watt power supply is required. However, the average power drawn by a Navigator pinging at its maximum rate at maximum altitude is 3 Watts for a 1200 kHz, 5 Watts for a 600 kHz and 16 Watts for a 300 kHz. This is based on an input voltage of 32 volts. There is a constant background power consumption of 2.2 watts for the processing electronics as long as the Navigator does not "go to sleep."

The average power consumption depends upon the transmit duty cycle which is a function of many factors. For a Navigator pinging at its maximum rate, the maximum duty cycle is about 13%. By reducing the ping rate, the duty cycle is reduced and therefore overall power consumption may be reduced.

The Navigator contains a 10 mF capacitor, which provides filtering of the high power consumption during transmit. This means that the Navigator should not be adversely affected by reasonable variations in the power supply voltage. It also means that the Navigator should not unduly affect the power supply circuit.

Peak current drawn by the Navigator is never more than 3 amps due to a current limiting circuit that is provided to prevent blowing a 3 amp internal fuse. At start up this translates to 96 Watts at 32V input.

Note that the power supply must be able to provide at least 13 volts continuously at a current draw of 0.15 amps to get the processor started.

Can I externally trigger the DVL?

There are now three methods of triggering the DVL. The third is a new development and is described here for completeness although it is only available on firmware version 9.13 and above.

1. **Sending ASCII Character Through Serial:** The system can be setup to wait for input before each ping. To setup the DVL in this fashion, clear the Auto Ping Cycle bit in the CF command by sending CFx0xxx, where the x's represent the settings of the other parameters (see "CF - Flow Control," page 154). Start the DVL pinging with the CS command. The DVL will output a '<' before each ping and wait for input. Send any valid ASCII character to trigger the ping. The instrument will not enter sleep mode while it is waiting for the trigger.
2. **Using Master-Slave RDS^3:** Using RDS^3, the instrument can be setup as a slave. In slave mode, the DVL can be commanded to remain awake at all times or it can be allowed to enter sleep mode between pings. If the DVL is allowed to sleep, then the latency from trigger to ping is greatly extended (on the order of 100 msec). To use

you must have the DVL configured for RS-232 communications. Set the SM command to slave mode by sending SM2. Start the DVL pinging with the CS command. The DVL will then wait for a trigger before pinging. Different ping synchronization rules are available – see "SA - Synchronize Before/After Ping/Ensemble," page 192. Setting the RS-485 lines to a break state for not less than 20 msec sends the trigger (see "Ping Synchronization Commands," page 192).

3. **Using Low-Latency Triggering:** The trigger methods above all have latencies ranging from a few milliseconds to a few hundred milliseconds. Consequently, TRDI has recently developed a low-latency trigger method (see "CX – Low Latency Trigger Enable," page 158). To configure the DVL for low-latency triggering, set the CX command to enable trigger input by sending CX1. Start the DVL pinging with the CS command. The DVL will then wait for a trigger before each ping. Setting the RS-485 lines to a break state for not less than 10 microseconds sends the trigger. The DVL will then ping within 250 microseconds of the leading edge of the break pulse (See also "FSA-018 - Triggering a DVL with a TTL Signal," page 337).

Synchronization with another sensor?

There are currently two ways to synchronize the Navigator with another sensor.

1. Setup the system to ping on command through the RS232 or RS422 serial lines, i.e. send a carriage return, a TAB or a CS to ping (see "Can I externally trigger the DVL? ," page 37, first Triggering solution above).

2. Setup the system to be triggered via a short pulse through the RS485 serial lines (see "Can I externally trigger the DVL? ," page 37, and RDS[3] and Low-Latency Triggering solutions above). Note that this implies the DVL uses RS232 communications only.

How can I interface with my acoustic positioning system?

The DVL communicates via a serial line. The protocol can be either RS232 or RS422. The data outputted on this serial line can be chosen so it can be decoded by your positioning system. NMEA0183 output string is available and is detailed below. See also NMEA data output format description (see "Navigator NMEA Output (PD11)," page 261).

Will my vehicle magnetic properties affect the accuracy of the DVL compass?

The DVL uses a flux gate compass. Flux gate compasses are biased by materials with magnetic properties (such as iron) or by induced magnetic fields (such as motors). It is possible to calibrate out the effects of magnetic materials that do not produce high magnetic fields and remain in a fixed position relative to the DVL. Motors and moving magnetic fields cannot be calibrated out. See "AF – Field Calibrate Compass," page 135 to learn more about how to calibrate your internal compass in the field. Note that calibration has to be done with the DVL mounted on/in the vehicle, which itself would have to be stable to avoid motion due to water and far from a ship's hull, power supply, running motor or even CRT PC screens to avoid nearby strong magnetic fields preventing successful calibration.

How do I select RS232 or RS422 communication?

An internal switch on the top board of the DVL board stack makes selection between RS232 or RS422 communications (see Figure 17, page 69). You have to open the system to modify the selection. By default the unit is in RS232.

Is the DVL power ground floating? Is the DVL chassis isolated from communication lines and/or power?

There are three isolated non-floating Grounds in the DVL: Power, Communication and Chassis Grounds. The power is isolated from the communication lines. The chassis is isolated from both of these. There is fuse protection for both input power and the communication lines in case the cable is cut or shorted. There is no protection for user equipment connected on the other end of the cable.

Is the data line floating with respect to ground? Is it Opto isolated?

With respect to power and chassis ground there is complete isolation. Therefore, to maintain isolation users should not share data common and power common. Sharing lines defeats the isolation and create ground loops effect. In RS232 mode data common to data in is >2.8kohm. In RS422 mode data common is >20kohm except to data out which is >2.8kohm.

Is the communication circuit protected from shorting or over voltage?

The serial line fuses actually open up when they heat up and then they close again as they cool.

Do I get more data if I increase communications speed?

No, but you increase the speed at which you receive the data, i.e. the baud rate. One way to increase this rate is to speed up the baud rate. A typical one ping ensemble size is 195 bytes for bottom track only. It will take about 0.2 seconds to transmit at 9600 Bauds/sec and 0.01 seconds at 115000 bauds/sec.

NOTE. Note that the collection of the bottom track data varies based on the distance to the bottom. The further off the bottom you are, the longer the ping takes. The time it takes to transfer the data is fixed by the amount of data to be sent and the baud rate.

Indeed, consider a typical DVL user sets one ping per ensemble (ping cycle including data processing). Therefore, a ping and an ensemble are the same thing. A ping should be thought of as 3 distinct parts:

Measurement cycle - that is, transmit and receive sound (variable)

Data processing (fixed)

and another part that transfers out this information from the serial port (variable)

The Navigator can typically collect a bottom track data point and transfer the data once per second at 9600-baud rate.

NOTE. The Navigator will not transmit another ensemble until it has finished the previous ensemble.

Can I apply an external time stamp on the data?

The DVL has its own real time clock. The DVL does not accept a clock input. However, it is possible to periodically set the clock using TS command (see “TS – Set Real-Time Clock,” page 200) or TT for Y2K compliant clock time (see “TT – Set Real-Time Clock (Y2k Compliant),” page 201). During clock setting the DVL data collection would be momentarily halted.

What is the timing relationship between the DVL internal clock and the time of the Doppler bottom tracking measurement?

The actual measurement of velocity occurs when the transmitted sound reflects from the bottom. We take our measurement from the midpoint of the reflected signal, so the time of the DVL measurement for practical purposes is one half of the transmit pulse duration plus the one way travel time to the bottom. The length of the transmit pulse is typically 30% of the two way travel time to the sea bottom, however it can be limited by the BX command setting (see “BX – Maximum Tracking Depth,” page 150). The travel time in water is dependant on depth and speed of sound in water.

The Doppler measurement occurs after the time tag as shown below:

After time tag = (1/ C Cos J) *ms/meter* x (Altitude *meters* + min (0.3 x Altitude *meters*, 0.015 x BX command *in decimeters*)).

Example 1: The BX command limits the size of the transmit pulse.

Altitude = 20 m,

BX command set to 30 m,

C (speed of sound) = 1471 m/s

J (Beam angle) = 30°

0.78 x (20 + min (0.3 x 20, 0.015 x 300))

0.78 x (20 + min (6, 4.5)) = 19 ms

Example 2: The transmit pulse duration reaches 30% of the two-way travel time before the BX limit is reached.

Altitude = 12 m, BX command set to 30 m, C= 1471, J (Beam angle) = 30°

0.78 x (12 + min (0.3 x 12, 0.015 x 300))

0.78 x (12 + min (3.6, 4.5)) = 12 ms

Additionally, the DVL accepts external NMEA0183 heading data up to 10Hz or uses an internal compass (see “FSA-017 - Using NMEA Heading Strings,” page 334). The DVL takes the latest heading sensor data from the buffer just prior to time tagging the ensemble and transmitting a pulse. Therefore external heading data used in the output data string typically occurs some time before the DVL time tag.

4.10.3 Frequently Asked Operational Questions

How do I deploy my DVL?

Deploying your DVL means to set it up properly based on the task needed and based on the environmental parameters. The best and easiest way to set-up your DVL is to use *PlanADCP*. By simply answering a few questions about your deployment, *PlanADCP* will create a command file to set-up your DVL to the most fitted configuration (see “Creating a Command File Using PlanADCP,” page 122). You can modify *PlanADCP* suggested set-up if needed, and save the command file as a script file (*.txt for simplicity). You can also create your own command/script file based on the command descriptions provided in this manual (see “Command Descriptions,” page 130). Remember to always start with the CR1 command and finish with the CK command prior to CS command (see “Sample Printout of a Command File,” page 123).

Once the command/script file is created, you need to send it to the DVL in command mode, i.e. you sent a BREAK to the DVL and it is not pinging, through the serial communication port. Several options are available to do so and one of them is to use TRDI’s hyperterminal program *BBTalk*.

Here are the steps to send a command/script file to the DVL using *BBTalk*:

4. Run *BBTalk.*
5. Select your device: WorkHorse.

6. Select the port parameters: COMx, baudrate (9600 baud is the factory default), Parity none, Stop Bits 1, Flow Control None.
7. Check "**send a break on new connection**" and "**send CK on baudrate changes**" (Optional).
8. Send a break by clicking on *BBTalk* toolbar **B** button, or sending $B or pressing the **End** key of your keyboard. After reception of the break the DVL welcome message displays:

```
[BREAK Wakeup A]
Navigator Broadband ADCP Version 9.20
RD Instruments (c) 1996-2005
All Rights Reserved.
```

9. Press the **F2** key on your keyboard and select the script file you want to send to the DVL.
10. *BBTalk* sends each command included in the command file in the order they are in the file.

NOTE. The last command overrides an identical command sent previously.

11. You can use the TurnKey mode (see "CT - Turnkey Operation," page 157) to set the DVL to reload this set-up next time power is applied to it.

How do I correct for speed of sound?

There are several options:

1. The Navigator has a built in temperature sensor and optionally a pressure sensor that can be used to aid the speed of sound calculation.
2. The Navigator may accept the RS485 input of an Applied Microsystems Limited Sound Velocity Smart Sensor (SVSS) to correct for speed of sound. This may be achieved by using the DVL in RS232 and accepting the data in RS485 from the SVSS. Customers are advised to contact TRDI for further information on this interface as some modification to the DVL may be required.

CAUTION. The SVSS sensor must be tested with the DVL before deployment.

3. Another option is to fix the Speed of Sound at a standard value for example 1500m/sec, and correct the velocities externally for the correct value in post-processing using temperature, salinity and depth using equations such as: SOS = 4388 + (11.25 × temperature (in °F)) + (0.0182 × depth (in feet) + salinity (in ppt)).

4. Alternatively you can send the Navigator a fixed value from an external source.
5. Or, send the Navigator Salinity, Temperature, and Depth information and tell it to calculate using the EZ command (see “EZ - Sensor Source,” page 171).

If none of these options are possible, you can post-process the velocity to compensate for the incorrect SOS by using the following equation:

Vcorrected = Vuncorrected x (Creal/Cincorrect)

Where Creal is the trued speed of sound at the transducer and Cincorrect is the sound speed used by the unit.

You may use the following equation to compute Creal (Urick 1983):

$$C = 1449.2+4.6T - 0.055T^2 + 0.00029T^3 + (1.34 - 0.01T)(S-35)+0.016D$$

Where:

T is the temperature in ∘C
S is the salinity in parts per thousands
D is the depth in meters

Note that only the temperature at the transducer head is needed as the velocity measurement is not affected by the change in temperature in the water column considered.

What interference might I get between the DVL and the other acoustic equipment on my vehicle?

Interference from other acoustic devices can cause velocity errors. In extreme cases it can prevent the DVL from operating.

The DVL transmit bandwidth is 25% and the front end receive bandwidth (determined by the transducer) is 40% about the carrier frequency.

It is possible to avoid most interference by having an acoustic management scheme. If the primary, harmonics or sub-harmonics coincide between the DVL and other acoustic device, you will need to consider either synchronous or asynchronous triggering of these devices (see “FSA-018 - Triggering a DVL with a TTL Signal,” page 337). Your individual scenario will determine whether to use synchronous or asynchronous triggering.

Consideration should be given to:

1. Primary frequency
2. Harmonics
3. Bandwidth
4. Length of Transmit
5. Repetition rate

See also “Interference,” page 24.

What are the acoustic source levels for the Workhorse Navigator DVL?

The general formula for source level is:

SL = 170.8 + DI + 10*Log10(Acoustic Power).

For our systems:

DI = 20*Log10(pi*(Diameter of the transducer ceramic)/wavelength).

Acoustic Power = Electrical Power * Transducer Efficiency

Below is a table of these values.

Freq. (Nom.)	Freq. (Actual)	Xmit Bandwidth	XDCR Dia. (mm)	Pelec (watts)	Efficiency (%)	SL	Beamwidth (Deg.) (1 way)
300	307	76.75	73	25	52.00%	216.3	3.9
600	614	153.5	73	8	60.00%	217.1	2.0
1200	1229	307.25	51	3	40.00%	214.0	1.4

NOTES.

Frequencies & Bandwidths in kHz.
-3dB bandwidths are 25% of center frequencies
SL in dB re 1 uPa@1m

What are the maximum and minimum altitudes that my DVL will operate?

This is different for each frequency. It should be noted that maximum power output and therefore maximum range is only achieved at 50VDC input. However, the DVL is designed to achieve its specified performance (shown below) at 32VDC, 35ppt @5°C.

300kHz	Max 200m	Min 1.0m
600kHz	Max 90m	Min 0.7m
1200kHz	Max 30m	Min 0.5m (0.25m in Mode 7)

What are the maximum and minimum speeds that the DVL can detect?

Maximum velocity for the Workhorse Navigator is 10m/s (19.4 knots) with beam 3 pointing forward. However, by rotating the transducer head by 45° this can be increased to 14m/s (27.2 knots). TRDI can provide custom units capable of detecting higher velocities on request.

Minimum velocity is zero, which allows you to use it for station keeping (hovering). The DVL is able to provide very high-resolution data at very low velocities. At altitudes of less than a few meters from the seabed a special low altitude bottom tracking mode of the default bottom mode turns on automatically.

Table 9: Altitude Switch to Quiet Low Altitude Bottom Tracking mode (default Bottom Mode 5)

Frequency (KHz)	Altitude (m)
300	12
600	6
1200	3

What happens to the DVL output if I don't have bottom lock?

For output data formats PD0, PD3, PD4, PD5, PD6, PD10 and PD13 the velocities will go to -32768 when bottom lock is lost. PD11 will show empty fields should the velocity be flagged bad(-32768) due to Bottom Lock outages. Please note that we have four beams, but only require three beams for a solution, i.e. a three-dimensional velocity vector. Therefore if we lose one beam we can still calculate a solution. Also, note that the altitude data will go to zero should we lose bottom lock. The DVL will continue to operate and report data.

The DVL has the capability to track a water reference layer as well as the bottom. This capability allows the user to continue to navigate during limited bottom tracking outages. See "BK - Water-Mass Layer Mode," page 143 and "BL - Water-Mass Layer Parameters ," page 143 commands to control this feature.

How accurately can I navigate with my DVL?

Navigator specifications are shown in "Specifications," page 272.

There are two parameters stated for velocity.

Precision: random white noise

Accuracy: repeatable bias partially correctable by calibration and/or by Kalman filtering.

The Precision figure is a statement of random error that partially or entirely averages out over longer periods. Random errors are due to the random white noise(i.e. independent of previous measurement) on the velocity data measurement.

The Accuracy figure is a statement of repeatable error/noise non-reducible by averaging. It can be interpreted as consisting of two independently varying components: A static bias drift (i.e. ±b) and a scale factor of the measured variable (i.e. ±s%). The maximum error can therefore be expressed as the RMS combination of the two components.

Positional error, therefore, is the total RMS of the accuracy long term velocity accuracy multiplied by time.

Position Error = RMS (DVL Dynamic Bias x Travel Time, DVL Static Bias x Travel Time).

Here is a simple example with a 300KHz DVL:

DVL Accuracy = DVL Dynamic Bias + DVL Static Bias

Static Bias on velocity = measured at zero speed, the velocity static bias drift is **±2 mm/s**,

Dynamic Bias on velocity = ± 0.4% of DVL velocity,

Velocity = 1 m/s,

Travel Time = 1 hr

==

Position Error = **±0.4% x 1 m/s x 3600 s** + **±2 mm/s x 3600 s**

So, after one hour,

Distance Traveled = 3.6 km

Position Error = **±14.4 m** + **±7.2m** = ±11.4m

==

Since the bottom ping transmit length is 30% of the altitude of the vehicle to the bottom, the DVL short term accuracy will be improved at higher elevations as a greater transmit length will provide more measurement, resulting in a quieter measurement of the vehicle Speed Over Ground.

NOTE. High elevation limits the ping rate as the system has to wait for the signal to travel greater distances before being received for measurement, and therefore the velocity of the vehicle would have to be reduced to maintain the DVL accuracy.

Can I use the DVL around offshore structures?

Yes, a DVL operated around a structure is OK until the structure actually is illuminated by the sound transmission. Most times a vertical structure that is taller than the depth of the water being measured will not return a signal that can be used for the bottom tracking pulse and so will be ignored. This is because of the angle of incidence to the structure. However, if the structure is not vertical then it can return a signal. As long as the structure is not moving there should be no problems with the received signal during the bottom track detection.

A structure that is illuminated for the water reference layer (or speed through the water layer) will typically be ignored when it interferes with 2 or less beams. If two beams are ignored by the DVL, then no data will be outputted unless the EQ command is used to enable single beam data (see “EQ – Enable Single Beam Data,” page 168). However, if the structure interferes with three or four beams, then it will cause the DVL to measure its speed relative to the structure.

How do I calibrate my DVL?

TRDI performs a factory calibration of the transducers and sensors. No other calibration is normally required on the DVL itself unless the DVL is using an external heading sensor or internal in the proximity of magnetic fields.

If you are using the internal compass then you must calibrate the biases due to the vehicle magnetic signature (see "Compass Calibration," page 64). This is done by fully rotating the entire vehicle after installing the DVL in the vehicle. It will be necessary to rotate the vehicle at two different tilt angles when doing this calibration.

If you are using an external heading reference system (e.g. INS) it may be appropriate to calibrate the combined system against another independent system such as GPS.

Will it work in fresh water?

The DVL bottom track will work very well in fresh water, provided the bottom is within range of the DVL. Indeed, bottom track range is increased in fresh water. The water reference layer (speed through the water measurement) will not work in fresh water that is completely without suspended sediment. The DVL water reference requires that there be very small objects/scatterers such as zooplanktons in the water reflecting its transmitted sound in order for it to make a measurement. Fresh water (drinking water quality) can be too clear for the water reference layer to succeed. The same remark can be made for the Water Profiling feature of the DVL. However, the 1200 kHz DVL works well in fresh water lakes and rivers. It is sometimes necessary to set the salinity correctly for speed of sound calibration (see "ES – Salinity," page 169).

What is the maximum seabed slope that I can still bottom track?

The Navigator is designed to cope with seabed slopes of up to 20º assuming the DVL is level.

Do sand waves affect my ability to bottom track and measure altitude?

The DVL locates and then confirms the bottom by looking for a sharp rise in the returned signal strength. Water and zooplanktons typically return very weak signals compared to the bottom and so this intensity rise is easily detected.

The DVL will not necessarily know the difference between the true bottom or a sand wave, since both will cause a sharp rise in the returned signal.

Therefore, the DVL will measure the range to bottom as the range to the top (or bottom) of the sand wave. When this happens, the DVL will also measure the speed over the bottom as the speed of the vehicle less the speed of the sand wave in the direction of DVL motion. The same note can be made for certain types of moving grass over the bottom.

Do I need to reconfigure each time power is applied?

The Navigator automatically stores the last set of commands used in RAM (volatile memory). The user can store the configuration into non-volatile memory by sending a CK command (see “CK - Keep Parameters,” page 155). Note that the DVL will restart in the previous configuration even if it was not saved with a CK command as long as the volatile memory’s internal battery is not discharged. This can happen after several months without any power applied to the DVL (Note that this battery will recharge as soon as power is reapplied). If the Navigator is stopped by removing the power while pinging, it will restart pinging and output data next time power is applied.

> **NOTE.** Always use the CK command in your configuration file (see “Creating a Command File Using PlanADCP,” page 122).

Will Bottom Tracking be a problem over a pipe?

Depending on how the beams strike the pipe there may be problems.

When bottom tracking over a pipe at a close range, TRDI believes it would be best to have the DVL aligned so that beam 3 is forward. This means that two beams would be right over the pipe and the other two beams will either isonify the bottom or the pipe. Of course this will depend on the shape of the pipe, size of the pipe, and the distance off the pipe. If the pipe is small or the system is farther off the pipe, then beams 1 and 2 would isonify the bottom. If the pipe is large or the system is close to the pipe, then beams 1 and 2 could be isonifying the pipe at an angle causing the signal to be reflected away from the DVL.

When bottom tracking over a pipe at a reasonable/selectable range, TRDI believes it would be best to have Beam 3 with a 45 azimuth offset with the vehicle centerline and to set the vehicle altitude so that all beams isonify the bottom rather than the pipe. This configuration will avoid causing the beams to isonify the pipe and having little to none of the intensity return to the beam, making velocity and range measurement impossible.

Using the new EQ command for bottom tracking over specifically difficult structures such as pipes or ship hulls is recommended for consideration since it will allow to output data without being flagged bad by our signal quality processing program (see "EQ – Enable Single Beam Data," page 168).

What is the maximum rate that I can ping?

Maximum Update Rate = 1/Minimum Ensemble Time

Minimum Ensemble Time = Total number pings per ensemble x time per ping x data transfer time

Where:

Total number pings per ensemble = (Water pings + Bottom Track Pings) per ensemble

Minimum time per ping = Nominal (vertical) range x 1.57 ms/m

Data transfer rate = Baud rate/(10 x number of bytes per ensemble)

What is the maximum pulse length?

The pulse length is 30% of the range to bottom or of BX if smaller.

For example, 30% of 200m = 60m yields a maximum pulse length of

(60*1.57 = 94.2 ms).

It should be noted that when the range to bottom equals or exceeds 50% of the BX command value entered, then the transmit pulse length is limited to 15% BX (see "BX – Maximum Tracking Depth," page 150).

The pulse length may be modified if necessary in the special NarrowBand Bottom Mode 6 or High Resolution Bottom Mode 7 (see "BM - Bottom Track Mode," page 144). However, reductions in the pulse length may affect the Navigators ability to reliably bottom track some seabed materials / conditions and increase standard deviation, i.e. increase random noise.

Is there an angular rate limit for the accuracy spec?

The effect of increased angular motion is to increase the standard deviation of each individual ping rather than effecting long term accuracy. Our broadband systems have extremely good performance on single ping precision due to our patented broadband processing and therefore this is not typically a concern.

In addition to the above, you should note that considerable levels of roll or pitch (>20 degrees) may result in the decorrelation of some pings. As we use narrow acoustic beams to achieve the highest possible accuracy, the transmitted signal may not be received back at the transducer if the angular motion is high (roll or pitch rate) combined with high roll / pitch angles. This effectively would reduce the number of bottom tracking pings that would be reported from the DVL. We use the BC command to set a correlation threshold in our DVL. We set a default (recommended by TRDI), however this threshold may be overridden (reduced) if you expect increased motion (see "BC - Correlation Magnitude Minimum," page 139).

Which data format should I use and why?

The Navigator can output data in several user selectable formats. Depending on the output format selected, data will be either binary or ASCII text. Individual parameters within a data string may be enabled / disabled. All binary output formats have the option of outputting data in HEX-ASCII instead of true binary. HEX-ASCII is an ASCII representation of the binary data. Binary output formats include PD0, 3, 4, 5 and 10. Text output formats include PD6, 8, 9, 11, and 13.

Example of the PD6, format:

`:TS,99033123021467,35.0,+13.6, 0.1,1500.0,`	Time +.....
`:BI, +717, -676, +28, -12,A`	Navigator movement relative to the bottom
`:BS, +716, -678, -10,A`	Ship movement relative to the bottom
`:BE, +963, +211, -10,A`	Ship movement, East, North, vertical
`:BD, +25.51, +2.61, -0.14, 4.19, 2.00`	Distance data and range to the bottom
`:SA, +5.13, -1.86,304.35`	System attitude. (Pitch and Roll)

The DVL comes with several different data formats that allow different levels of information. Deciding on which format to use depends on the needs of the vehicle operation. The following describes the basics of the formats available. For detailed information on these data formats please refer to the "Binary Output Data Format," page 213 section**.**

The following formats allow the output of bottom track, speed through the water, and current profile data:

PD0 – This is TRDI's standard format. PD0 is a binary output format. It provides the most information possible including a header, fixed and variable leader, bottom track, and water profile information. The fixed and variable leader is a recording of time, DVL setup, orientation, heading, pitch, roll, temperature, pressure, and self test diagnostic results. Data fields to be output are user selectable.

File Size (if BT Only) is 211 bytes binary

File Size (if water profile included) varies depending on the number of bins selected.

PD3 – PD3 is a binary output format of bottom track speed over the bottom, speed through the water, range to bottom information, and 16 spare bytes with no definition.

File Size is 40 bytes binary.

PD4 – PD4 is a binary output format of bottom track speed over the bottom, speed through the water, and range to bottom information only.

File Size is 28 bytes binary.

PD5 – PD5 is a superset of PD4 and includes information on salinity, depth, pitch, roll, heading, and distance made good.

File Size is 74 bytes binary.

PD6 – PD6 is a text output format. Data is grouped into separate sentences containing system attitude data, timing and scaling, and speed through the water relative to the instrument, vehicle, and earth. Each sentence contains a unique starting delimiter and comma delimited fields

PD10 is similar to PD3 but with the addition of pressure and depth fields.

PD11 is a text output format. It complies with the NMEA 0183 version 2.30 standard.

PD13 – is a text output format similar to PD6 with the addition of information about range to bottom and raw pressure sensor data.

The following table is a summary of the type of data outputted by each PD data output format. Note that this is an exhaustive list and it is advised to check out the full description of a format before choosing it above another. For detailed information on these data formats please refer to the "Binary Output Data Format," page 213 section.

Table 10: Summary of Output Data Formats

	PD0	PD3	PD4	PD5	PD6	PD10	PD11	PD13
System Info	✓		✓	✓				
Temperature	✓	✓	✓	✓	✓	✓		✓
Depth	✓			✓	✓	✓	✓	✓
Tilts (H, P, R)	✓	✓		✓	✓	✓	✓	✓
Time of Ping	✓	✓	✓	✓	✓	✓		✓
Speed of Sound	✓		✓	✓	✓			✓
Water Profile configuration	✓							
Water Profile Velocities	✓							

	PD0	PD3	PD4	PD5	PD6	PD10	PD11	PD13
Correlation Magnitude	✓							
Echo Intensity	✓							
Percent Good	✓							
Bottom Range	✓	✓	✓	✓	✓	✓	✓	✓
Bottom Velocity (SOG)	✓	✓	✓	✓	✓	✓	✓	✓
Water-Mass Layer Velocity (STW*)	✓	✓	✓	✓	✓	✓		✓
Bottom Track Configuration	✓							
Distance Over Ground				✓				
Binary	✓	✓	✓	✓	✓	✓		
ASCII					✓			✓
NMEA							✓	

*STW=Speed Through Water

Data outputted through the serial and recorded on the Recorder Card:

Additionally, if using a Recorder Card (by default the system comes without a recorder card – see “PC Card Recorder,” page 69), the fact that the data outputted is not necessarily the same as the one recorded should be considered. The following table recalls what is outputted from the serial port and what is recorded on the recorder for each data output format as for firmware version 9.20:

Table 11: Summary of Recorded Data for Output Data Format Type

Data Output Format	Serial Output	Recorded On PC Recorder Card
PD0	PD0	PD0
PD3	PD3	None
PD4	PD4	PD4
PD5	PD5	PD5
PD6	PD6	None
PD10	PD10	None
PD11	PD11	PD0
PD13	PD13	None

NOTE. This table is subject to change in the future, please contact TRDI Field Service for more information about possible changes in firmware post version 9.20. Note also that when downloading a new firmware, the README.TXT file will give you information on what has been changed and/or fixed from firmware version 9.20 to the one you are downloading.

Data Format in TRDI DVL:

The following rules are used in creating our BroadBand Data Format of PD0. Our recommended decoding sequence is presented next.

Rules for the BroadBand Data Format PD0:

a. All data types (i.e. fixed leader, variable leader, velocity, echo intensity, correlation, percent good, etc.) will be given a specific and unique ID number.

b. Once a data type has been given an ID number the format of the data inside that ID number will never change in units, order, or number of bytes.

c. Data may be added to an existing data type only by adding the bytes to the end of the data format. As an example, the variable leader data contains information on ensemble number, time, heading, pitch, roll, temperature, pressure, etc. The format for the bytes 1-53 are now specified by changes added in support to the WH ADCP. If additional sensor data is to be added to the variable leader data then it must be added to the end of the data string (bytes 54-x as an example).

d. The order of data types in an ensemble is not fixed. That is there is no guarantee that velocity data will always be output before correlation data.

e. The header data will include the number of data types in the files and the offset to each ID number for each data type.

f. The total number of the bytes in an ensemble minus the 2 byte checksum will be included in the header.

Recommended Data Decoding Sequence for BroadBand Data Format PD0:

1. Locate the header data by locating the header ID number (in the case of PD0 profile data that will be 7F7F).
2. Confirm that you have the correct header ID by:
    a. Locating the total number of bytes (located in the header data) in the ensemble
    b. Add 2 bytes to the value in 2a. This will be your offset to the next ensemble.

   c. Read the 2 bytes following the offset to the next ensemble (calculated in step 2b).
   d. Confirming that the next 2 bytes are the header ID number. If it is then you have located the Header ID. If not then go back to step 1 and search for the next header ID number occurrence.
3. Locate the number of data types (located in the header data).
4. Locate the offset to each data type (located in the header data).
5. Locate the data ID type you wish to decode by using the offset to each data type and confirm the data ID number at that offset matches the ID type you are looking for.
6. Once the proper ID type has been located use the DVL Technical Manual for the DVL you are using to understand what each byte represents in that particular data type.

What are the Navigator NMEA Output Specifications

1.0 Introduction

The Navigator's PD11 output data format is compliant with the data format and structure provisions of the NMEA 0183 version 2.30 standard. Where possible an attempt has been made to conform to the structure of Approved Sentences (NMEA 0183, 5.3.1) although Proprietary Sentences (NMEA 0183, 5.3.3) are defined in this document

2.0 Sentence Structure

So far there exist three sentences containing sensor and navigational data. TRDI may add additional sentences in the future, so care should be taken to correctly identify the sentence by it's ID.

2.1 $PRDIG - Sensor Data

The sensor data sentence consists of heading, pitch, roll, and depth below surface. Each data field is preceded by an identifier indicating the contents of the following field. All values are in SI units. All data fields are variable width. Empty data fields indicate missing or invalid data. TRDI may add additional fields in the future. Any such additional fields will be added after the last field in this specification and before the checksum.

```
$PRDIG,H,x.x,P,x.x,R,x.x,D,x.x*hh<CR><LF>
_ _ _ _ _ _ _ _ _ _ _ _ _ _ _depth
_ _ _ _ _ _ _ _ _ _ _ _ _ _depth ID
_ _ _ _ _ _ _ _ _ _ _roll
_ _ _ _ _ _ _ _ _ _roll ID
_ _ _ _ _ _ _ _pitch
_ _ _ _ _ _ _pitch ID
_ _ _ _ _heading
_ _ _ _ heading ID
_ NMEA 0183 header
```

2.2 $PRDIH - Bottom-Track Navigational Data

The bottom-track data sentence consists of range to the bottom, speed over ground, and course over ground. Each data field is preceded by an identifier indicating the contents of the following field. All values are in SI units. All data fields are variable width. Empty data fields indicate missing or invalid data. TRDI may add additional fields in the future. Any such additional fields will be added after the last field in this specification and before the checksum.

```
$PRDIH,R,x.x,S,x.x,C,x.x*hh<CR><LF>
_ _ _ _ _ _ _ _ _ _ _ _course over ground
_ _ _ _ _ _ _ _ _ _ _course over ground ID
_ _ _ _ _ _ _ _ _ speed over ground
_ _ _ _ _ _ _ _ speed over ground ID
_ _ _ _ _ _ range to bottom
_ _ _ _ _ range to bottom ID
_ NMEA 0183 header
```

2.3 $PRDII – Water Referenced Navigational Data

The water referenced navigational data sentence consists of speed relative to the water current and course relative to the water current. Each data field is preceded by an identifier indicating the contents of the following field. All values are in SI units. All data fields are variable width. Empty data fields indicate missing or invalid data. TRDI may add additional fields in the future. Any such additional fields will be added after the last field in this specification and before the checksum. A “water layer” ping is required in the ensemble sequence to output water referenced data. See “BK - Water-Mass Layer Mode,” page 143 and “BL - Water-Mass Layer Parameters ,” page 143 commands for details.

```
$PRDII,S,x.x,C,x.x*hh<CR><LF>
_ _ _ _ _ _ _ _course relative to water
_ _ _ _ _ _ _course relative to water ID
_ _ _ _ _speed relative to water
_ _ _ _speed relative to water ID
_ NMEA 0183 header
```

3.0 Usage Notes

The NMEA output format is enabled by setting the DVL output format to PD11. Data will continue to be recorded to the internal recorder in PD0 format if the recording bit is set in the CF command to CFxxxx1. Note that the x’s stand for either 0 or 1. Note that the DVL will ignore the serial output bit in the CF command, i.e. CFxxx**X**x, when PD11 is set. The PD formats are discussed more fully in “Which data format should I use and why? ,” page 50.

NOTE. To get valid water-reference data, BK1 must be set in the DVL.

Below is an example of a valid sensor data sentence showing a heading of 197.34°, a pitch angle of -10.2°, a roll angle of -11.5° and a depth of 122.7m.

```
$PRDIG,H,197.34,P,-10.2,R,-11.5,D,122.7*7E<CR><LF>
```

Below is an example of a valid bottom-track sentence that contains range to bottom of 143.2m, a speed over ground of 1.485 m/s, and a course over ground of 192.93°.

```
$PRDIH,R,143.2,S,1.485,C,192.93*17<CR><LF>
```

Here is an example of a bottom-track sentence with invalid or missing data.

```
$PRDIH,R,,S,,C,*05<CR><LF>
```

This last example shows a water-reference sentence that contains speed relative to current of 1.503 m/s and a course relative to current of 203.5°.

```
$PRDII,S,1.503,C,203.5*55<CR><LF>
```

How Does the Navigator Sample Depth and Pressure?

a. For each ping, the ADC samples the pressure sensor five times and averages the data. This is an attempt to reduce the Standard Deviation.

b. Using the Pressure coefficients, the pressure data from the ADC is converted to kPa.

c. That data is converted to dm and corrected for salinity with the following equation:

   Depth (dm) = Pressure (kPa) * (1.02-0.00069*ES), where ES is the Salinity setting.

   This is the depth value recorded in the PD0 variable leader when the DVL is fitted with a pressure sensor and that the EZ command is set to EZx1xxxxx.

d. The pressure data is converted from kPa to deca-Pascals by multiplying it by 100. This value in deca Pascals is recorded in the PD0 variable leader data.

Converting kpa to Depth

The formula for converting kpa to depth (using *WinADCP*) is as follows:

Depth = (kpa(1.02-0.00069*Salinity)*(1000/Water Density))/10

5 Maintenance

This section explains how to prepare the Navigator for deployment, how to do certain maintenance procedures, and how to prepare the Navigator for storage or shipment.

Table 12, page 82 lists the items in the tools and spares parts kit. Use this kit when doing routine Navigator maintenance.

NOTE. When an addition or correction to the manual is needed, an Interim Change Notice will be posted to our web site on the Customer Service page (www.rdinstrument.com). Please check our web site often.

5.1 I/O Cable and Dummy Plug

The underwater connector (on the end-cap) and the I/O cable and dummy plug are molded wet-mate-able connectors. The end-cap connector is a factory-installed item. We do not recommend removing it for any routine maintenance.

NOTE. The dummy plug should be installed any time the I/O cable is removed. Use the dummy plug when the Navigator is in storage or is being handled.

5.1.1 Disconnecting the I/O Cable or Dummy Plug

The cable should be disconnected with a straight outward motion only. Use the following procedure to disconnect the cable.

CAUTION. When disconnecting the Navigator I/O cable, do not apply any upward force on the connector as it is being pulled off. Applying an upward angle as the cable is disconnected puts stress on the connector. This may cause several serious problems: a) The connector or connector pins can crack. b) The O-ring on the bottom of the connector can be damaged. c) The molded urethane on the connector may separate from the brass insert. **If the connector is damaged in any of these ways, your DVL will flood.**

a. Release the retaining strap by pulling it over the connector.

b. Grasp the cable close to the end-cap/mounting flange (see Figure 14, page 58). Your thumb should rest against the edge of the housing.

c. Pull the cable straight out away from the housing with a gentle side-to-side rocking motion. Do not apply any upward force on the connector as it is being disconnected.

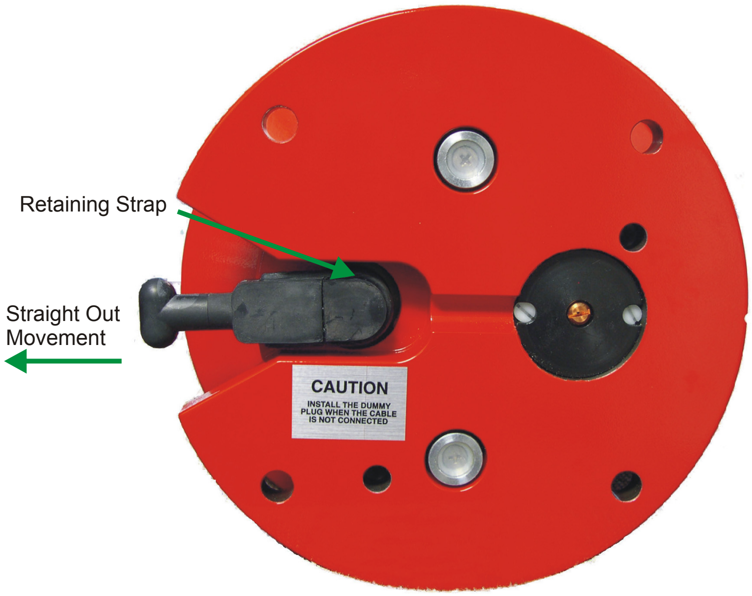


Figure 14. Removing the I/O Cable

5.1.2 Connecting the I/O Cable or Dummy Plug

The cable should be connected with a straight inward motion only. Use the following procedure to connect the cable.

> **CAUTION.** When connecting the Navigator I/O cable, do not apply any upward force on the connector as it is being pushed on. Applying an upward angle as the cable is connected puts stress on the end-cap connector. This may cause several serious problems: a) The end-cap connector or connector pins can crack. b) The O-ring on the bottom of the end-cap connector can be damaged. c) The molded urethane on the end-cap connector may separate from the brass insert. **If the end-cap connector is damaged in any of these ways, your DVL will flood.**

a. Apply a light coat of DC-111 lubricant to the rubber portion of the end-cap connector pins. This will help seat the connector.

b. Gently push the cable straight in toward the end-cap connector. Do not apply any upward force on the connector as it is being connected.

c. Roll the retaining strap over the connector.

5.2 Navigator Disassembly

This section explains how to remove and replace the housing to gain access to the DVL's electronics, and optional internal recorder PC cards. Read all instructions before doing the required actions.

> **NOTE.** TRDI does not recommend opening the Navigator just to "look inside." Once opened, the O-rings and desiccant should be replaced.

5.2.1 Housing Removal

a. Remove all power to the Navigator.

b. Remove the I/O cable and place the dummy plug on the I/O cable connector (see "I/O Cable and Dummy Plug," page 57).

c. Stand the Navigator on its end-cap.

d. Loosen and remove the four bolts (8-mm) that attach the housing flange to the transducer head assembly.

e. Carefully lift the transducer assembly straight up and away from the housing until you can gain access to the connector jack on the common mode choke. Use care; the mating surfaces scratch easily. Do not damage the mating surfaces.

> **NOTE.** The cable attached to the end cap is only long enough to disconnect the internal I/O cable. There is NOT enough cable to set the transducer down next to the Housing Assembly.

f. Squeeze the sides of the internal I/O cable connector to release it from the common mode choke jack. Set the end-cap assembly aside. Set the transducer assembly (transducer face down) on a soft pad.

g. Clean the O-ring mating surfaces with a soft, lint-free cloth. Inspect the surfaces for damage (see "O-ring Inspection and Replacement," page 60).

h. When you are ready to re-assemble the Navigator, see "Navigator Re-assembly," page 59.

5.3 Navigator Re-assembly

To replace the housing, proceed as follows. Use "Parts Location Drawings," page 83 for parts identification.

a. If you are sealing the Navigator for a deployment, be sure you have done all appropriate maintenance items (see "Sealing the Navigator for a Deployment," page 74).

b. Make sure all printed circuit boards, spacers, cables, and screws have been installed.

c. Inspect/replace the O-rings before closing the Navigator (see "O-ring Inspection and Replacement," page 60).

d. Install two fresh bags of desiccant just before closing the Navigator (see "Desiccant Bags," page 70).

5.3.1 O-ring Inspection and Replacement

This section explains how to inspect/replace the Navigator O-rings. A successful deployment depends on the condition of the O-rings and their retaining grooves. See "Parts Location Drawings," page 83 for the locations of the following O-rings. Read all instructions before doing the required actions.

Transducer assembly, bore 2-258

Transducer assembly, face 2-260

Transducer assembly, backup O-ring, 8-258 N300-90

NOTE. The backup O-ring is installed on both 3000 and 6000 meter systems in addition to the 2-258 bore O-ring on the transducer/end cap assembly. Install the backup O-ring with the cupped side facing the 2-258 bore seal O-ring (see Figure 15, page 61).

We strongly recommend replacing these O-rings whenever you disassemble the Navigator. Inspecting and replacing the O-rings should be the last maintenance task done before sealing the Navigator.

NOTE. We recommend you use new O-rings if you are preparing for a deployment.

a. Inspect the O-rings. When viewed with an unaided eye, the O-rings must be free of cuts, indentations, abrasions, foreign matter, and flow marks. The O-ring must be smooth and uniform in appearance. Defects must be less then 0.1 mm (0.004 in.).

CAUTION. If the O-ring appears compressed from prior use, replace it. **Weak or damaged O-rings will cause the DVL to flood.**

b. Clean and inspect the O-ring grooves. Be sure the grooves are free of foreign matter, scratches, indentations, corrosion, and pitting. Run your fingernail across damaged areas. If you cannot feel the defect, the damage may be minor; otherwise, the damage may need repair.

CAUTION. Check the O-ring grooves thoroughly. **Any foreign matter in the O-ring grooves will cause the DVL to flood.**

c. Lubricate the O-ring with a thin coat of silicone lubricant (Table 12, page 82). Apply the lubricant using latex gloves. Do not let loose fibers or lint stick to the O-ring. Fibers can provide a leakage path.

NOTE. TRDI uses Dow Corning's silicone lube model number 111 but any equivalent type of silicone O-ring lube can be used.

CAUTION. Apply a **very thin** coat of silicone lube on the O-ring. Using too much silicone lube on the O-ring can be more harmful than using no O-ring lube at all.

d. The backup O-ring (see Figure 15) is installed in addition to the 2-258 bore O-ring on the transducer head assembly for 3000, and 6000-meter systems. Install the backup O-ring with the cupped side facing the 2-258 bore seal O-ring.

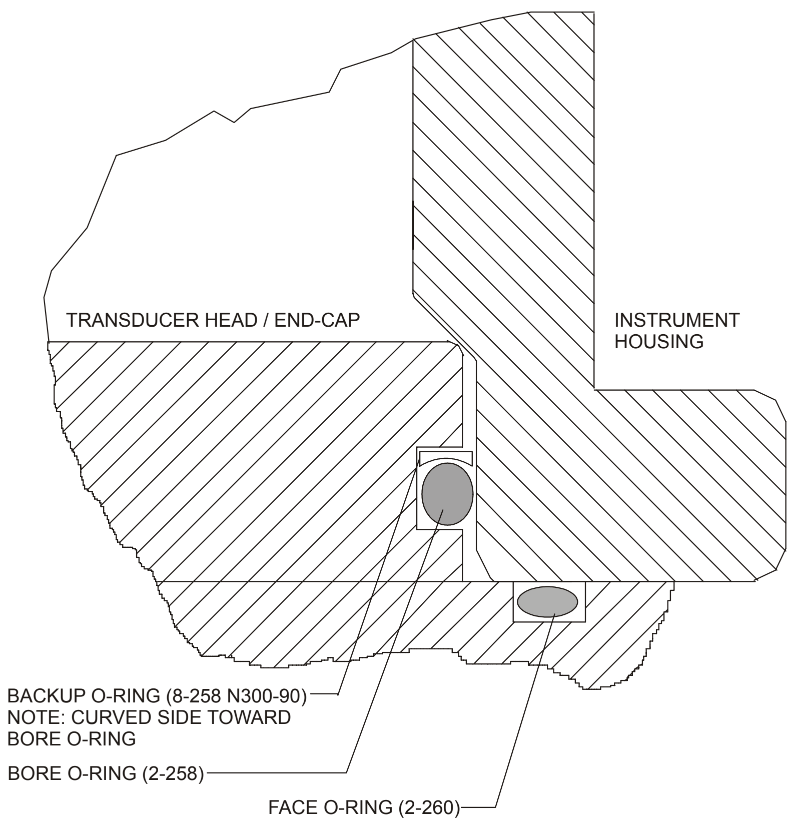


Figure 15. O-Ring Detail View

5.3.2 Housing Assembly Replacement

a. Stand the Navigator on its end-cap/mounting flange.

b. Inspect, clean, and lubricate the O-rings on the housing (see "O-ring Inspection and Replacement," page 60). Apply a very thin coat of silicone lube on the O-rings.

> **NOTE.** We recommend you use new O-rings if you are preparing for a deployment.

> **NOTE.** TRDI uses Dow Corning's silicone lube model number 111 but any equivalent type of silicone O-ring lube can be used.

> **CAUTION.** Apply a **very thin** coat of silicone lube on the O-ring. Using too much silicone lube on the O-ring can be more harmful than using no O-ring lube at all.

c. Connect the internal I/O connector to the plug on the common mode choke.

d. Gently lower the transducer head/electronics assembly into the housing, aligning the mating holes and the Forward mark on the transducer head with the Forward mark on the end-cap. When mating the housing with the transducer head flange try to apply equal pressure to all parts of the O-ring. Make sure the face and bore O-rings remain in their retaining grooves.

> **CAUTION.** Check that no wires or any other object is pinched between the transducer head assembly and the housing. Use rubber bands to hold the wiring in place as necessary. **If the O-ring is not in the groove or if a wire or other object is pinched, the DVL will flood.**

e. Examine the transducer assembly nuts, bolts, and washers (8-mm) for corrosion; replace if necessary. The "Parts Location Drawings," page 83 shows the assembly order of the transducer mounting hardware. All hardware items are needed to seal the Navigator properly.

f. Install all four sets of hardware until "finger tight."

g. Tighten the bolts in small increments in a "cross" pattern until the split washer flattens out, and then tighten each bolt ¼ turn more to compress the face seal O-ring evenly. Tighten the bolts to the recommended torque value of 9.6 Newton-meters (85 pound-inches). Do not deform the plastic bushings.

> **CAUTION.** Apply equal pressure to the O-ring as you tighten the bolts. If one bolt is tightened more then the others, the O-ring can become pinched or torn. **A damaged O-ring will cause the system to flood.**

CAUTION. Do not over tighten the bolts that hold the transducer, and housing together. If you tighten too far, you can crack or break the plastic bushing. On the other hand, leaving the bolts too loose can cause the system to flood. **Tighten the hardware to the recommended torque value.**

NOTE. The recommended torque value for the transducer head 8-mm bolts is 9.6 Newton-meters (85 pound-inches).

5.3.3 Optional External Battery Case Battery Replacement

The optional external battery case holds two battery packs to provide power. Batteries should be replaced when the voltage falls below +30 VDC (measured across the battery connector under no-load conditions). To replace the battery packs, do the following steps.

CAUTION. The external battery case should not be connected or disconnected underwater. The electrical output power will degrade the connector contacts and present a potential electrical shock hazard to installation personnel when the power connector is short-circuited in water. The external battery case output power cannot be enabled or disabled underwater.

a. Remove one end-cap from the external battery pack (see Figure 22, page 84).

b. Place the external battery case on its side and carefully pull out the battery pack (attached to the end-cap).

c. Disconnect the battery power cable from the wiring harness.

d. Remove the four wing nuts, lock washers, and washers holding the battery pack onto the posts (see “Parts Location Drawings,” page 83).

e. Remove the support plate.

f. Slide out the used battery pack.

g. Slide a new battery pack onto the four posts. Make sure the wiring harness is not pinched by the battery pack. Use the large rubber bands (supplied with each new pack) to hold the cables in place.

h. Position the support plate over the four posts.

i. Place a flat washer, lock washer, and wing nut on each of the four posts. Tighten the nuts to hold the battery in place.

j. Test the battery pack voltage by measuring across the battery connector under no-load conditions. The voltage should be +42 VDC for a new battery pack.

k. Connect the battery power cable to the wiring harness.

l. Install the end-cap/battery pack assembly.

m. Repeat steps "a" through "l" to replace the other battery pack.

n. Replace the desiccant bags on each battery just before sealing the external battery case (see "Desiccant Bags," page 70).

5.4 Compass Calibration

The main reason for compass calibration is battery replacement. Each new battery carries a different magnetic signature. The compass calibration algorithm corrects for the distortions caused by the battery to give you an accurate measurement. You should be aware of the following items:

We recommend against calibrating the Navigator while on a ship. The ship's motion and magnetic fields from the hull and engine will likely prevent successful calibration.

If you think your mounting fixture or frame has some magnetic field or magnetic permeability, calibrate the Navigator inside the fixture. Depending on the strength and complexity of the fixture's field, the calibration procedure may be able to correct it.

> **NOTE.** If only the battery modules were removed and replaced back in the same orientation, the compass does not require calibration. If the battery cores were replaced, you **must** verify the compass.
>
> Battery replacement induces both single and double cycle compass errors. The compass accuracy should be verified after replacing the battery pack. The compass does not have to be recalibrated if the compass verification passes specification.
>
> These compass effects can be avoided by using an external battery pack. The external battery housing holds two batteries, and can easily be replaced on-site. If properly used, no compass calibration will be required. The external battery pack provides an option for extended DVL deployments.

5.4.1 Preparing for Calibration

a. Place the Navigator on a piece of strong cardboard on top of a smooth wooden (non-magnetic) table. If a wooden table is not available, place the Navigator on the floor as far away from metal objects as possible. Use the cardboard to rotate the Navigator during calibration—this way you will not scratch the Navigator. Place the DVL in the same orientation as it will be deployed.

> **NOTE.** If you will deploy your Navigator looking up, calibrate it looking up. If you will deploy it looking down, calibrate it looking down.

CAUTION. If you calibrate the compass in one direction (up or down) and deploy the DVL in the opposite direction (i.e. calibrate it in a downward position and deploy it in a upward position) the compass calibration will be invalid. Compass errors in excess of 5 degrees may occur.

b. Connect the Navigator as shown in Figure 3, page 11.

c. Start *BBTalk*. See the RDI Tools User's Guide for assistance on using *BBTalk*.

5.4.2 Compass Calibration Verification

Compass calibration verification is an automated built-in test that measures how well the compass is calibrated. The procedure measures compass parameters at every 5º of rotation for a full 360º rotation. When it has collected data for all required directions, the Navigator computes and displays the results.

NOTE. Verify the compass if you have just replaced the memory module, or any ferrous metals is relocated inside or around the Navigator housing. Calibrate the compass if the batteries have been replaced (see "Compass Calibration Procedure," page 66).

a. Prepare the DVL for calibration (see "Preparing for Calibration," page 64).

b. Using *BBTalk,* send a Break to wake up the Navigator.

c. At the ">" command prompt enter **AX** and press the return key.

d. When prompted, rotate the Navigator slowly 360 degrees (approximately 5 degrees per second). Pay particular attention to the Overall Error. For example;

```
HEADING ERROR ESTIMATE FOR THE CURRENT COMPASS CALIBRATION:
   OVERALL ERROR:
      Peak Double + Single Cycle Error (should be < 5():   ( 1.55(
   DETAILED ERROR SUMMARY:
      Single Cycle Error:                                 ( 1.54(
      Double Cycle Error:                                 ( 0.07(
      Largest Double plus Single Cycle Error:             ( 1.61(
      RMS of 3rd Order and Higher + Random Error:         ( 0.31(
```

If the overall error is less than 2°, the compass does not require alignment. You can align the compass to reduce the overall error even more (if desired).

5.4.3 Compass Calibration Procedure

The built-in automated compass calibration procedure is similar to the alignment verification, but requires three rotations instead of one. The Navigator uses the first two rotations to compute a new calibration matrix and the third to verify the calibration. It will not accept the new matrix unless the calibration was carried out properly, and it asks you to verify that you want to use the new calibration if it is not as good as the previous calibration. While you are turning the Navigator for the two calibration rotations, the Navigator checks the quality of the previous calibration and displays the results. It compares these results with the results of the third calibration rotation.

There are two compass calibrations to choose from; one only corrects for hard iron while the other corrects for both hard and soft iron characteristics for materials rotating with the DVL. Hard iron effects are related to residual magnetic fields and cause single cycle errors while soft iron effects are related to magnetic permeability that distorts the earth's magnetic field and causes double cycle errors. In general, the hard iron calibration is recommended because the effect of hard iron dominates soft iron. If a large double cycle error exists, then use the combined hard and soft iron calibration.

a. Prepare the DVL for calibration (see “Preparing for Calibration,” page 64).

b. Using *BBTalk,* send a Break to wake up the DVL.

c. At the “>” command prompt enter **AF** and press the return key.. When the calibration procedure starts, choose the calibration type.

d. Tilt the DVL (see Figure 16, page 67). Tilt an upward-looking Navigator with a block under one side of the end-cap. A 35-mm thick block will give you an 11-degree tilt. Check the on-screen instructions to see if the orientation is OK. Adjust as necessary.

> **NOTE.** The tilts must remain constant during the rotations. The transducer beam is the center point of the rotation.

e. When prompted, rotate the DVL slowly 360 degrees (approximately 5 degrees per second).

f. The second rotation requires the DVL to be tilted 15 degrees in another direction than from the first rotation (see Figure 16, page 67). Follow the on-screen instructions to orient the DVL correctly. When prompted, rotate the DVL slowly 360 degrees (approximately 5 degrees per second).

g. The third rotation requires the DVL to be tilted 15 degrees in another direction than from the first and second rotations. Follow the on-screen instructions to orient the DVL correctly.

h. If the calibration procedure is successful, it records the new calibration matrix to nonvolatile memory. The DVL will not change its matrix unless the calibration is properly carried out.

i. If the calibration procedure is not successful, return your DVL to the original factory calibration, by using the AR-command. Try using the AR-command if you have trouble calibrating your compass. In some circumstances, a defective compass calibration matrix can prevent proper calibration.

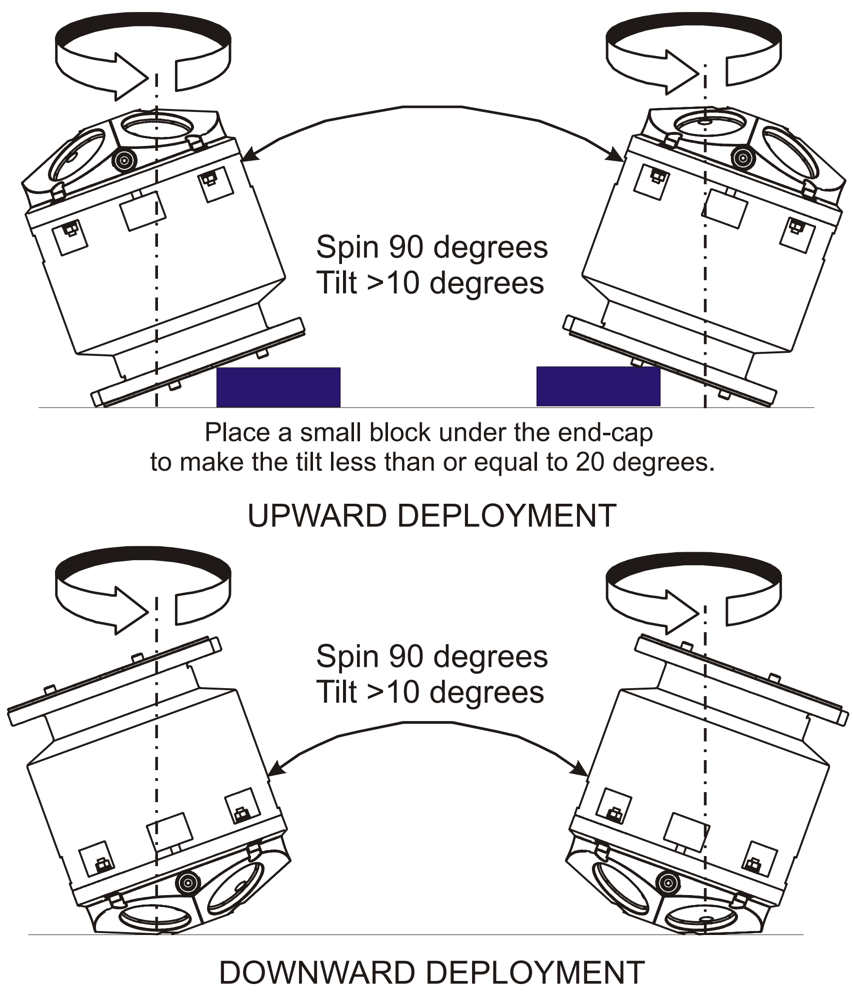


Figure 16. Compass Calibration

5.5 Fuse Replacement

PIO Board. There is one fuse on the PIO Board that protects the Navigator from excessive incoming power. If this fuse continues to blow, check your input power before applying power again (see “Fuse,” page 96).

a. Turn off the power.

b. Remove the housing (see “Navigator Disassembly,” page 59).

c. The PIO board fuse is located next to the internal I/O connector. Use a small flat-blade screwdriver to open the fuse housing. Turn the end 180° (counter-clockwise) to open the fuse housing.

d. Gently pull the fuse housing out. Turn the housing to remove the fuse.

e. Check the fuse using an ohmmeter. Replace the fuse if necessary with the correct voltage and amperage fuse (Table 12, page 82).

f. Install the housing (see “Navigator Re-assembly,” page 59).

g. Test the system (see “Testing the Navigator,” page 85).

External Battery Pack. One fuse in the external battery pack protects the Navigator from excessive incoming power. If this fuse continues to blow, check your battery packs before connecting the external battery case again.

a. Remove one end-cap from the external battery pack.

b. Carefully lift out the battery pack (attached to the end-cap).

c. Check the fuse using an ohmmeter. Replace the fuse if necessary with the correct voltage and amperage fuse (Table 12, page 82).

d. Install the end-cap.

e. Measure the voltage output of the external battery case across pin 3 (+) and pin 7 (-) on the external connector. If both battery packs are fresh, you should measure approximately +42 VDC.

5.6 Communications Setting

A switch on the PIO board (see Figure 17) changes the communication settings between RS-232 and RS-422. Your computer and the Navigator must both be set to the same communication setting. Use the RS-232-to-RS-422 converter if the Navigator is using RS-422 communications and you computer only has an RS-232 COM port.

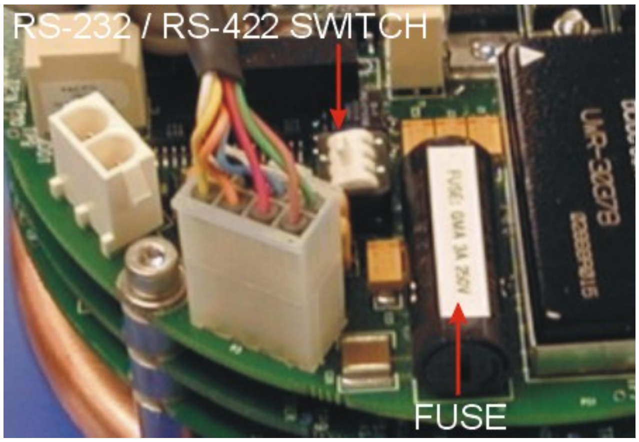


Figure 17. Communication Switch and Fuse

5.7 PC Card Recorder

NOTE. Memory cards are not included with the Navigator DVL. Two PCMCIA memory card slots are available, with the total memory capacity not to exceed 2GB.

The optional PC Card recorder is located on the Digital Signal Processor (DSP) board inside the Navigator's electronics (see Figure 18, page 70). To recover data, the card can be removed and used in a personal computer (PC), or left in the Navigator, and accessed by using *WinSC* (see the *WinSC* User's Guide). To remove or install a PC card, do the following.

a. Turn off power to the Navigator.

b. Remove the housing (see "Navigator Disassembly," page 59).

c. Remove the PC cards by pushing the button on the side of the PCMCIA card slot. The card should "pop" out of the connector. If you cannot reach the release button with your finger, use a plastic pen or other non-conductive tool to depress the button. Do not try to force the card in or out of the connector. PC cards slide easily in or out when properly oriented.

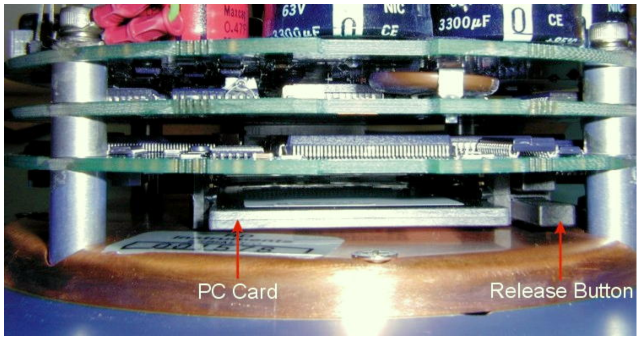


Figure 18. PC Card Recorder

d. When you are finished recovering the data, install the PC card back into the DSP board. PC cards install with the label side toward the face of the transducer.

e. Install the Housing (see "Navigator Re-assembly," page 59).

> **NOTE.** TRDI uses and sells true 16-bit PCMCIA/ATA, 5-volt, type 2 memory cards made by Envoy or SimpleTech. Other cards may work but TRDI cannot guarantee it will since it will depends on the card driver, information that is not always provided by the constructor in the part number. If you buy PCMCIA cards outside of TRDI, your best chances are to verify the card is ATA Type 2 FAT16 up to1Gb. To get a quote for a PCMCIA card supported by TRDI please contact TRDI Field Service or Sales (see "Technical Support," page 107).

5.8 Desiccant Bags

Desiccant bags are used to dehumidify the housing interior. Desiccant is essential in deployments with plastic housings. The factory-supplied desiccant lasts a year at specified Navigator deployment depths and temperatures. Remember that desiccant rapidly absorbs moisture from normal room air.

The average dry weight of a new desiccant bag is 7.2 grams ((5%). The weight increases to 8.4 to 9 grams for a "used" desiccant bag. Used desiccant bags may be dried at 250° for 14 hours. As a minimum, replace the desiccant bags (Table 12, page 82) whenever you are preparing to deploy or store the Navigator for an extended time.

> **CAUTION.** Do not open the desiccant bag. Contact with the silica gel can cause nose, throat, and skin irritation.

> **NOTE.** Desiccant bags are shipped in an airtight aluminum bag to ensure maximum effectiveness. There is a moisture indicator inside the bag. If the moisture indicator is pink, do not use the desiccant bag until it has been dried. TRDI recommends replacing the desiccant bag just before the deployment.

a. Remove the housing (see "Navigator Disassembly," page 59).

b. Remove the new desiccant bags from the airtight aluminum bag.

c. Remove the old desiccant bags and install two new ones. Place the desiccant bags (Table 12, page 82) between the PIO board and the end-cap.

d. Install the transducer head (see "Navigator Re-assembly," page 59).

5.9 Zinc Anode Inspection and Replacement

Navigator systems have six sacrificial zinc anodes. If the DVL does not have exposed bare metal, properly installed anodes help protect the DVL from corrosion while deployed. Read all instructions before doing the required actions.

5.9.1 Zinc Anode Inspection

The life of a zinc anode is not predictable. An anode may last as long as one year, but dynamic sea conditions may reduce its life. Use a six-month period as a guide. If the total deployment time for the anodes has been six months or more, replace the anodes. If you expect the next deployment to last six months or more, replace the anodes. Inspect the anodes as follows.

a. Inspect the anodes on the housing for corrosion and pitting. If most of an anode still exists, you may not want to replace it.

b. Inspect the RTV-covered screws that fasten each anode. If the RTV has decayed enough to let water enter between the screws and the anode, replace the RTV.

c. If you have doubts about the condition of the anodes, remove and replace the anode.

5.9.2 Zinc Anode Electrical Continuity Check

Check electrical continuity using a Digital Multi-Meter (DMM). All measurements must be less than five ohms. If not, reinstall the affected anode.

Housing Anodes. Measure the resistance between both anodes. Scratch the surface of the anode with the DMM probe to make good contact if the anode is oxidized. The resistance should be less than five ohms.

Transducer Anode. Remove the housing. Measure the resistance between the anodes and any one of the screws holding the electronics to the transducer mounting plate. The resistance should be less than five ohms.

5.9.3 Zinc Anode Replacement

The following steps explain how to remove and replace the zinc anode/s.

a. Remove the RTV from the anode screw heads. Remove the screws.

b. The anode may stick to the DVL because of the RTV used during assembly. To break this bond, first place a block of wood on the edge of the anode to protect the housing anodizing and paint. Carefully strike the block to loosen the anode.

c. Clean the bonding area under the anode. Remove all foreign matter and corrosion. Apply a continuous 1-2 mm bead (0.04-0.08 in.) of RTV around each screw hole.

d. Set a new anode in place and fasten with new screws.

e. Fill the counter bore above each screw head with RTV. The RTV protects the screw heads from water and prevents breaking the electrical continuity between the anode, screw, and housing.

f. Check electrical continuity. If any measurement is greater than one ohm, reinstall the affected anode.

> **CAUTION.**
>
> 1. Do not use zinc anodes with an iron content of more than 0.0015%. The major factor controlling the electrical current output characteristics of zinc in seawater is the corrosion film that forms on the surface of the zinc. Corrosion product films containing iron have a high electrical resistance. As little as 0.002% iron in zinc anodes degrades the performance of the anode.
>
> 2. Do not use magnesium anodes. Magnesium rapidly corrodes the aluminum housing.
>
> 3. Do not connect other metal to the DVL. Other metals may cause corrosion damage. Use isolating bushings when mounting the DVL to a metal structure.

5.10 Protective Coating Inspection and Repair

TRDI uses paint on the housing for identification and corrosion protection. For more protection, the case and the transducer assembly are first anodized. Do not damage the surface coatings when handling the DVL. Inspect and repair the protective coating as follows. Read all instructions before doing the required actions.

> **NOTE.** The procedures contained in this section apply to our standard aluminum systems. For systems made of other materials, contact TRDI.

a. Inspect the end-cap, housing, and transducer assemblies for corrosion, scratches, cracks, abrasions, paint blisters, exposed metal (silver-colored aluminum), exposed anodize (black or dark green), and exposed primer (yellow). Be critical in your judgment; the useful life of the Navigator depends on it.

> **CAUTION.** The chemicals used in the following steps can be hazardous to your health. Read all material safety data sheets and manufacturer's instructions before handling these chemicals.

b. If you are familiar with the repair of anodized coatings, proceed as follows; otherwise, send the Navigator to TRDI for repair.

   1. Clean and prepare the damaged area using a fine-grade abrasive cloth or a fine-grade abrasive silicon carbide wheel. Remove all corrosion from the bare aluminum.
   2. Clean the area with trichlorethane or alcohol. Do not touch the area after cleaning.
   3. Anodize per MIL-A-8625, Type 3, Class 1.
   4. Seal with sodium dichromate only.
   5. Paint repaired area as described in step c below.

c. Proceed as follows to repair or touch up the protective paint.

   1. Remove all loose paint without damaging the anodizing. Clean and prepare the damaged area using a fine-grade abrasive cloth. Feather the edges of the paint near the damaged area. Try to have a smooth transition between the paint and the damaged area. Do not sand the anodized area. If you damage the anodizing, see step b above for repair.
   2. Clean the area with trichlorethane or alcohol. Do not touch the area after cleaning.
   3. Paint with one coat of epoxy primer (manufacturer's part number 4500; see note below).
   4. Paint with one coat of orange or black paint (manufacturer's part number 4512-B (orange), 4511-B (black); see note below).

> **NOTE.** TRDI uses two-part epoxy type paint. This paint is manufactured by Pro-line Paint Manufacturing company, 2426 Main St., San Diego, CA, 92113, Telephone: (619) 231-2313; or 1168 Harbor, Long Beach, CA, 98813, Telephone: (213) 432-7961. Manufacturer's part numbers:
> 4500-A, Pro-thane Paint, Catalyst, Part A
> 4511-B, Pro-thane Paint, Black, Part B
> 4512-B, Pro-thane Paint, Orange, Part B

5.11 Sealing the Navigator for a Deployment

Use the "Parts Location Drawings," page 83 and the following steps to seal the Navigator for a deployment.

a. Check the Navigator electronics; there should be no loose screws or missing hardware.

b. Install the PC card(s) (optional, see "PC Card Recorder," page 69)

c. Add a fresh desiccant bag inside the Navigator housing (see "Desiccant Bags," page 70).

d. Install the housing assembly (see "Navigator Re-assembly," page 59).

e. The Navigator is now ready for deployment unless you want to take steps to prevent biofouling (see "Prevention of Biofouling," page 74).

f. Use "Setup the Navigator," page 11 to connect the Navigator system. Use "Testing the Navigator," page 85 to test the Navigator before the deployment.

5.12 Prevention of Biofouling

This section explains how to prevent the buildup of organic sea life (biofouling) on the transducer faces. Objects deployed within about 100 meters (≈328 feet) of the surface are subject to biofouling, especially in warm, shallow water.

Deep Water Deployments. Biofouling is not usually a problem in deep water (more than 100 meters). Soft-bodied organisms usually cause no problems. Do not apply antifouling grease if deploying the Navigator in deep water.

Shallow Water Deployments. Soft-bodied organisms usually cause no problems, but barnacles can cut through the urethane transducer face causing failure to the transducer and leakage into the Navigator (see Figure 19, page 75).

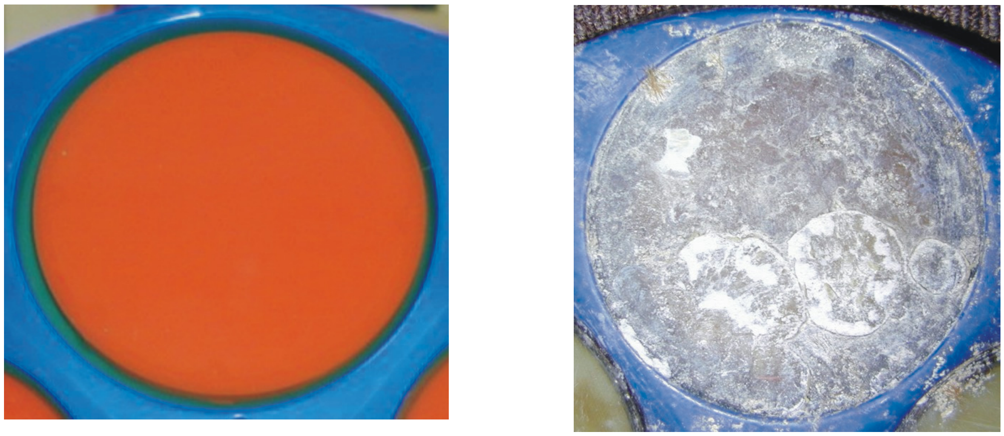
In shallow-water applications, the use of antifouling grease may be appropriate if you cannot clean the transducer faces often (weekly), and if the antifouling grease meets all of your local safety and environmental laws.

5.12.1 Controlling Biofouling

The best-known way to control biofouling is cleaning the Navigator transducer faces often. However, in many cases this is not possible. The following options can help reduce biofouling.

Coat the entire Navigator with the recommended antifouling paint. Make sure that the paint is applied in an even coat over the transducer faces.

Apply a thin coat (≈4 mm; ≈0.16 in.) of either a 50:50 mix of chili powder and petroleum jelly or chili powder and silicone grease to the transducer faces. The chili powder should be the hottest that can be found. Water flowing across the transducers will wash this mix away over time. The silicone mixture tends to last longer.



BEFORE AFTER

Figure 19. Barnacle Damage

> **CAUTION.** Barnacles can cut through the urethane transducer face causing failure to the transducer and leakage into the Navigator.

If using antifouling grease, remove the grease immediately after recovering the Navigator from its deployment. Remove the grease with soapy water. Be sure to wear protective gloves and a face shield.

> **CAUTION.**
>
> 1. Do not arbitrarily use antifouling grease for deep-water applications. For shallow-water applications, barnacles are a threat to the transducer faces; using antifouling grease may be appropriate if you cannot clean the Navigator regularly (weekly). If using antifouling grease, remove it immediately after recovering the Navigator.
> 2. Antifouling grease is toxic. Read the product safety data sheet before using the grease. Wear gloves and a face shield when applying the grease. If the skin comes in contact with the grease, immediately wash the affected area with warm, soapy water.
> 3. All U.S. coastal states prohibit the use of tributyl-tins on boat hulls. The European Economic Commission has released a draft directive that would prohibit the use of many organo-tins after July 1989. We strongly recommend you obey your local laws.

5.12.2 Antifouling Paints

You can use almost any EPA approved anti-fouling paint on the housing or the urethane transducer faces. You do have to be extra careful with the urethane faces. We have had success using the TRILUX II paint from Interlux.

Manufacturer	**Contact**
Courtalds Finishes	Telephone: 908-686-1300
Interlux brand paints	Web Page: www.interlux.com

5.12.3 Applying Antifouling Paints

Follow the urethane faces application instructions for TRILUX II. One thin coat can last for several months.

> **NOTE.** If you have an optional Navigator pressure sensor, and you want pressure (depth) data, you cannot protect the pressure sensor from biofouling. The pressure sensor is located near the center of the transducer array, between the urethane-covered transducers. The sensor port is a small hole drilled through a screw (see "Pressure Sensor Maintenance," page 77). You should tape off the screw during anti-fouling paint application.
>
> This means that the sensor port is not fully protected from bio fouling. The sensor port is surrounded by the antifouling paint, but bio fouling may build up on the screw, and eventually clog the sensor port. However, most organisms do not seem to find the small amount of unpainted surface attractive. If it is logistically possible to periodically inspect/clean the pressure sensor screw, it is highly recommended. This tradeoff situation must be analyzed for individual deployments. Unfortunately, the location of the deployment site usually dictates action in this regard.

Transducer Faces (urethane surfaces) and Plastic Housing

a. Preparation - Lightly sand by hand with 120-grit paper.

b. Application - Apply one or two coats of Trilux-2 at four mil/coat. If applying a second coat, wait at least 12 hours to allow the first coat to dry. One coat lasts one season (3-4 months); two coats might last one year.

Metal Surfaces (High Pressure Systems)

a. Metal Surface Preparation

   1. On bare aluminum metal, use 353/354 Vinylux solvent wash (thin with 355). Perform the Metal Surface Application (Step (b), below) between 1 and 24 hours.

   2. On painted surfaces, use 120-grit sandpaper to remove gloss.

b. Metal Surface Application

1. Mask as necessary.
2. Apply one or two coats of Trilux-2 (active ingredient is copper thiocyanate) at four mil/coat. If applying a second coat, wait at least 12 hours to allow the first coat to dry. One coat lasts one season (3-4 months); two coats might last one year.

NOTE. Do NOT use cuprous oxide on or near aluminum systems.

5.13 Pressure Sensor Maintenance

In order to read the water pressure, water must be able to flow through the copper screw on the pressure sensor. The tiny hole in the copper screw may at times be blocked. Use the following procedure and Figure 20, page 78 to clean the screw.

NOTE. The pressure sensor is optional. It may not be included on your system.

a. Place the DVL on its' face. Use a soft pad to protect the DVL.

b. Use a straight-slot screwdriver to remove the copper screw.

c. Gently clean out the hole in the copper screw with a needle. If the hole becomes enlarged or the screw is corroded, replace the screw. A replacement copper screw is included in the spare parts kit (part number 817-1067-00).

d. Install the copper screw. Tighten the screw "finger tight" (2 in/lbs). Do not over tighten the screw or you may strip the threads on the plastic cover disc. If this happens, return the DVL to TRDI for repair.

CAUTION.

The pressure sensor is filled with silicone oil. Never poke a needle or other object through the copper screw while the screw is installed over the pressure sensor. You will perforate the sensor, causing it to fail.

Do not remove the cover disc or attempt to clean the surface of the pressure sensor. The diaphragm is very thin and easy to damage.

Do not remove the pressure sensor. It is not field replaceable.

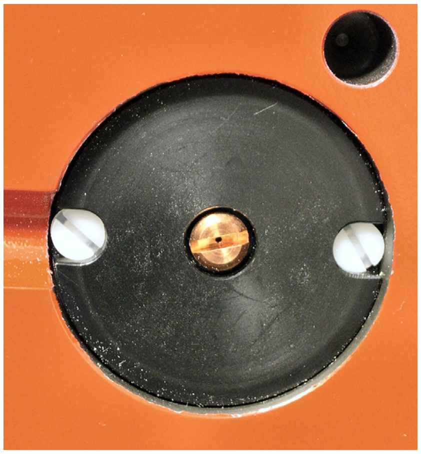


Figure 20. Navigator Pressure Sensor

5.14 Storage and Shipping Maintenance

This section lists the maintenance items to do before storing the Navigator. These maintenance items include:

Removing biofouling (see "Removal of Biofouling," page 78).

Inspecting the transducer head (see "Transducer Head Inspection," page 79).

Preparing the Navigator for final storage or shipping (see "Final Storage or Shipping Preparation," page 79).

⚠	**CAUTION.** Always dry the Navigator before placing it in the storage case to avoid fungus or mold growth. Do not store the Navigator in wet or damp locations.

⚠	**CAUTION.** Clean and inspect the I/O connector for water or salt residue. Make sure the dummy plug is installed to protect the connector.

5.14.1 Removal of Biofouling

Before storing or shipping the Navigator, remove all foreign matter and biofouling. Remove soft-bodied marine growth or foreign matter with soapy water. Waterless hand cleaners remove most petroleum-based fouling. Rinse with fresh water to remove soap residue. Dry the transducer faces with low-pressure compressed air or soft lint-free towels.

⚠	**CAUTION.** The soft, thin urethane coating on the transducer faces is easily damaged. Do not use power scrubbers, abrasive cleansers, scouring pads, high-pressure marine cleaning systems, or brushes stiffer than hand cleaning brushes on the transducer faces.

If there is heavy fouling or marine growth, the transducer faces may need a thorough cleaning to restore acoustic performance. Barnacles do not usually affect Navigator operation. We do however recommend removal of the barnacles to prevent water leakage through the transducer face. Lime dissolving liquids such as Lime-Away® break down the shell-like parts. Scrubbing with a medium stiffness brush usually removes the soft-bodied parts. Do NOT use a brush stiffer than a hand cleaning brush. Scrubbing, alternated with soaking in Lime-Away®, effectively removes large barnacles. After using Lime-Away®, rinse the Navigator with fresh water to remove all residues. If barnacles have entered more than 1.0 to 1.5 mm (0.06 in.) into the transducer face urethane, you should send the Navigator to TRDI for repair (see Figure 19, page 75). If you do not think you can remove barnacles without damaging the transducer faces, contact TRDI.

5.14.2 Transducer Head Inspection

The urethane coating on the transducer faces is important to Navigator watertight integrity. Mishandling, chemicals, abrasive cleaners, and excessive depth pressures can damage the transducer ceramics or urethane coating. Inspect the transducer faces for dents, chipping, peeling, urethane shrinkage, hairline cracks, and damage that may affect watertight integrity or transducer operation. Repair of the transducer faces should only be done by TRDI.

> **CAUTION.** Never set the transducer on a rough surface; always use foam padding to protect the transducers.

5.14.3 Final Storage or Shipping Preparation

This section explains how to store or ship the Navigator. Clean and inspect the I/O connector for water or salt residue.

> **CAUTION.** If you are shipping a Navigator to TRDI for repair or upgrade, remove all customer-applied coatings or provide certification that the coating is nontoxic. This certification must include the name of a contact person who is knowledgeable about the coating, the name, and manufacturer of the coating, and the appropriate telephone numbers. If you return the equipment without meeting these conditions, we have instructed our employees not to handle the equipment and to leave it in the original shipping container pending certification. If you cannot provide certification, we will return the equipment to you or to a customer-specified cleaning facility. All costs associated with customer-applied coatings will be at the customer's expense.

When shipping the Navigator through a Customs facility, be sure to place the unit/s so identifying labels are not covered and can be seen easily by the Customs Inspector. Failure to do so could delay transit time.

NOTE. TRDI strongly recommends using the original shipping crate whenever transporting the Navigator.

If you need to ship or store the Navigator, use the original shipping crate whenever possible. If the original packaging material is unavailable or unserviceable, additional material is available through TRDI.

5.15 Returning Navigators to TRDI for Service

When shipping the Navigator to TRDI from either inside or outside the United States, the following instructions will help ensure the Navigator arrives with the minimum possible delay. Any deviation from these instructions increases the potential for delay.

5.15.1 Domestic Shipments

Step 1 - Get a Return Material Authorization

The best way to make sure TRDI is aware of your intentions to ship equipment is to obtain a Return Material Authorization (RMA) before sending the shipment. Return Material Authorizations are issued by Sales Administration or Customer Service and are used to notify us of your needs in advance of arrival so we can provide a faster turnaround. When requesting a Return Material Authorization, please give us the following information.

What is being shipped (include the serial number)
When you plan to send the shipment
What problem(s) need correction
When you need the instrument returned

When the Return Material Authorization is issued, we will tell you the RMA number. Please include this number on all packages and correspondence.

Step 2 - Ship via air freight, prepaid

Urgent Shipments should be shipped direct to TRDI via any of several overnight or priority air services. Do not send urgent airfreight as part of a consolidated shipment. If you ship consolidated, you will save money, but may lose up to three days in transit time.

Non-urgent shipments may be shipped as part of a consolidated cargo shipment to save money. In addition, some truck lines may offer equivalent delivery service at a lower cost, depending on the distance to San Diego.

Mark the Package(s)

To: RD Instruments, Inc. (RMA Number)
14020 Stowe Drive
Poway, CA 92064

Step 3 - Urgent shipments

Send the following information by fax or telephone to TRDI.

Attention: Sales Administration
Fax: (858) 842-2822
Phone: (858) 842-2600

Detailed descriptions of what you are shipping (number of packages, sizes, weights, and contents).

The name of the freight carrier

Master Air bill number

Carrier route and flight numbers for all flights the package will take

5.15.2 International Shipments

Step 1 - Get a Return Material Authorization

The best way to make sure TRDI is aware of your intentions to ship equipment is to obtain a Return Material Authorization (RMA) before sending the shipment. Return Material Authorizations are issued by Sales Administration or Customer Service and are used to notify us of your needs in advance of arrival so we can provide a faster turnaround. When requesting a Return Material Authorization, please give us the following information.

What is being shipped (include the serial number)
When you plan to send the shipment
What problem(s) need correction
When you need the instrument returned

When the Return Material Authorization is issued, we will tell you the RMA number. Please include this number on all packages and correspondence.

Step 2 - Ship Via Air Freight, Prepaid

Urgent Shipments should be shipped direct. Do not send urgent airfreight as part of a consolidated shipment. If you ship consolidated, you will save money, but may lose up to five days in transit time.

Non-urgent shipments may be shipped as part of a consolidated cargo shipment to save money.

Mark the package(s) as follows:

To: RD Instruments, Inc. (RMA Number)
5 Avenue Hector Pintus
06610 La Gaude, France

Step 3 - Include Proper Customs Documentation

The Customs statement should be completed very carefully. It should accurately and truthfully contain the following information.

Contents of the shipment

Value

Purpose of shipment (example: "American made goods returned for repair")

Any discrepancy or inaccuracy in the Customs statement could cause the shipment to be delayed in Customs.

Step 4 - Send the Following Information by Fax or Telephone to TRDI

Attention: Sales Administration
Phone: +33(0) 492-110-930
Fax: +33(0) 492-110-931

Detailed descriptions of what you are shipping (number of packages, sizes, weights, and contents).

The name of the freight carrier

Master Air bill number

Carrier route and flight numbers for all flights the package will take

5.16 Spare Parts

Table 12: Navigator Spare Parts

Description	Part number
O-ring, face	2-260
O-ring, bore	2-258
O-ring, backup	2-258 N300-90, PARBAK
Desiccant, sealed bag	DES3
Lubricant, silicone, 4-pack	5020
Fuse, 3.0 Amp, 250V	GMA-3A

5.17 Parts Location Drawings

Use the following figures to identify the parts used on your Navigator DVL.

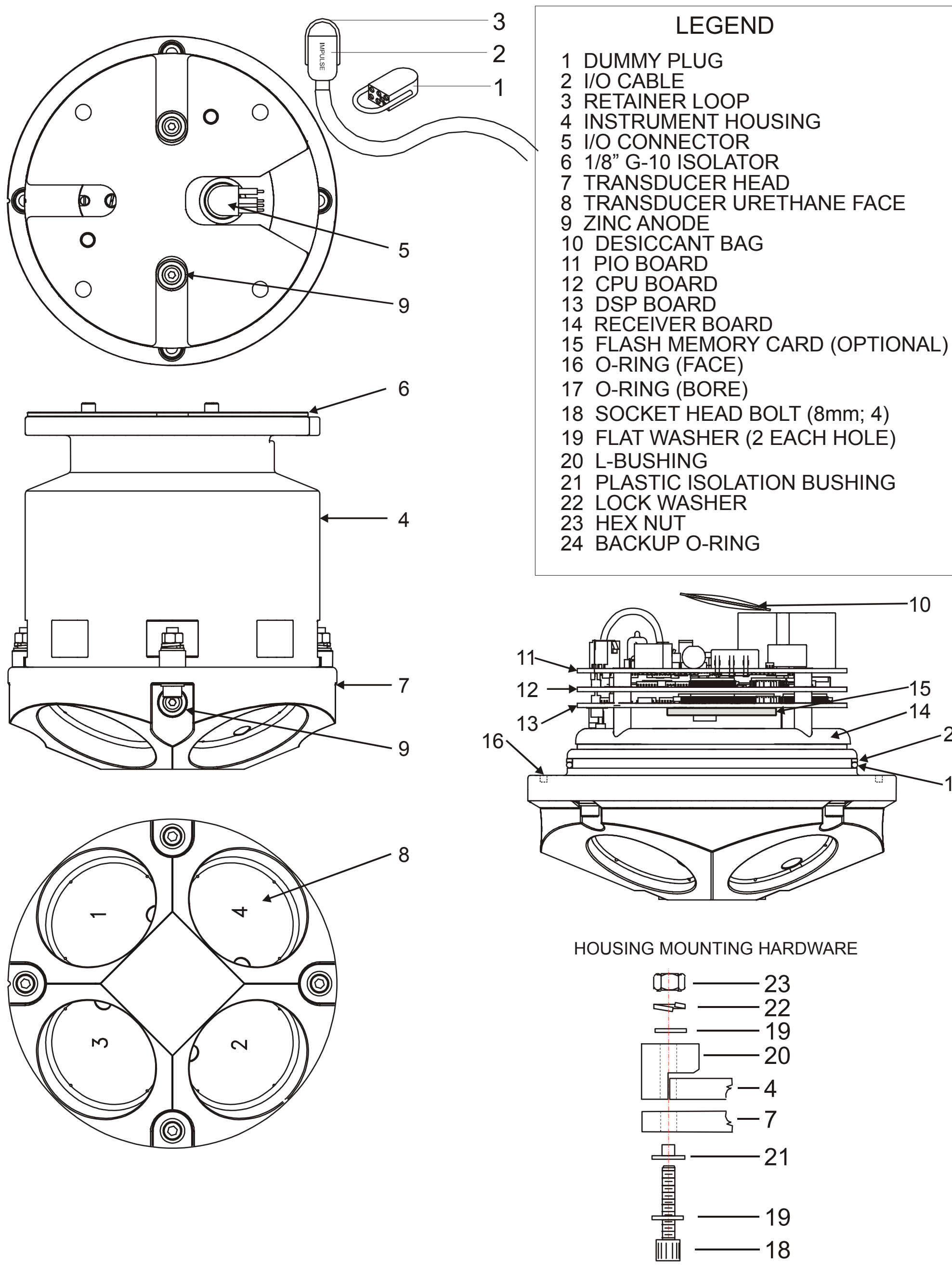


Figure 21. Navigator Parts Location

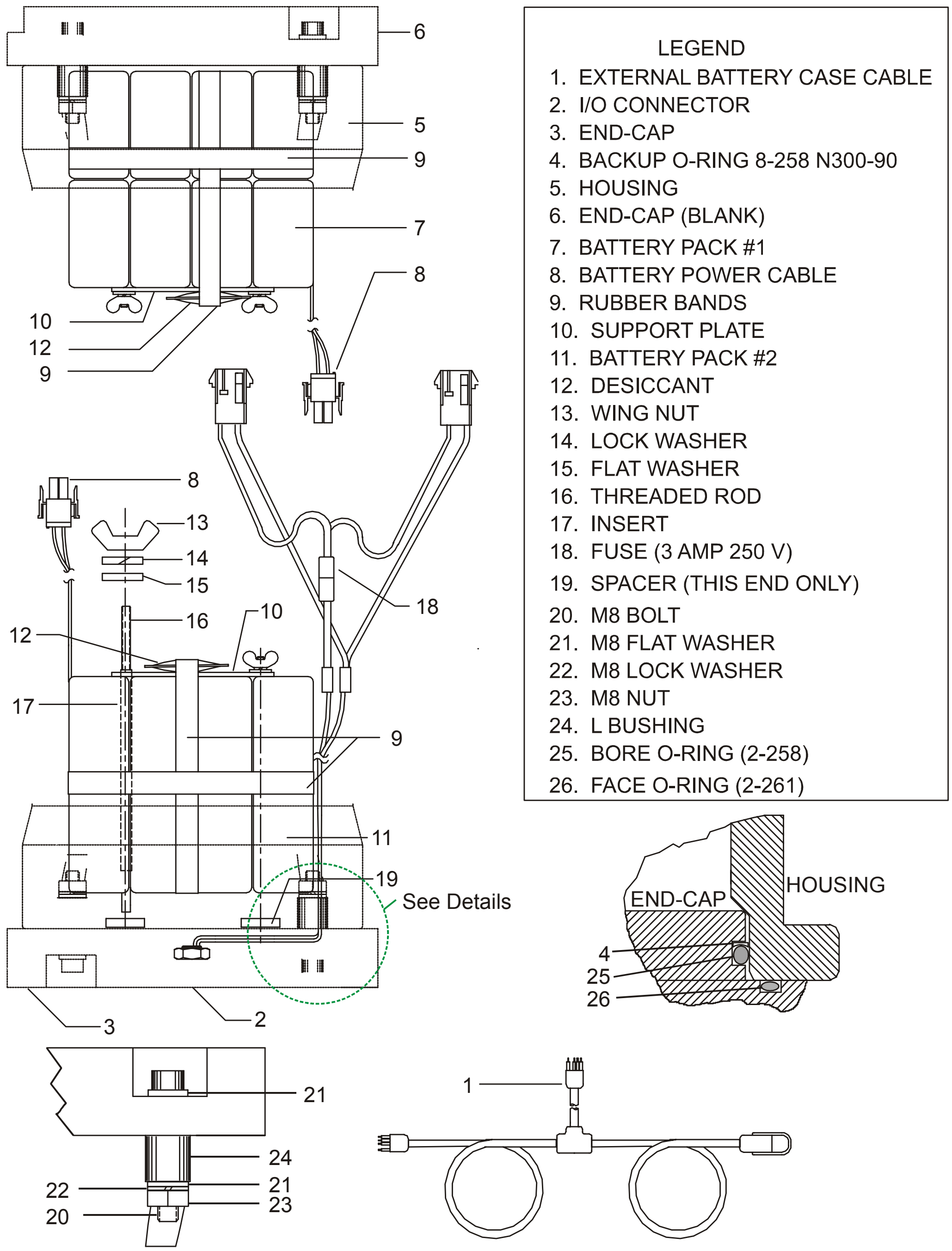


Figure 22. External Battery Pack Parts Location

6 Testing the Navigator

This chapter explains how to test the Navigator using the *BBTalk* program. These tests thoroughly check the Navigator in a laboratory environment, but are no substitute for a practice deployment. You should test the Navigator:

- When you first receive the Navigator.
- Before each deployment or every six months.
- When you suspect instrument problems.
- After each deployment.

These test procedures assume all equipment is working. The tests can help you isolate problems to a major functional area of the Navigator. For troubleshooting information, see "Troubleshooting the Navigator," page 92.

6.1 Testing the Navigator with *BBTalk*

Use the following steps to test the DVL.

a. Interconnect and apply power to the system as described in the "Setup the Navigator," page 11.

b. Start the *BBTalk* program (for help on using *BBTalk*, see the RDI Tools User's Guide).

c. Press **<F2>** and run the script file TestWH.rds. The TestWH.rds script file runs PS0, PS3, PA, PC2, and the PC1 tests. The results of the tests will be printed to the screen and saved to the log file WH_RSLTS.txt. The WH_RSLTS.txt file will be created in the same directory that *BBTalk* is running from.

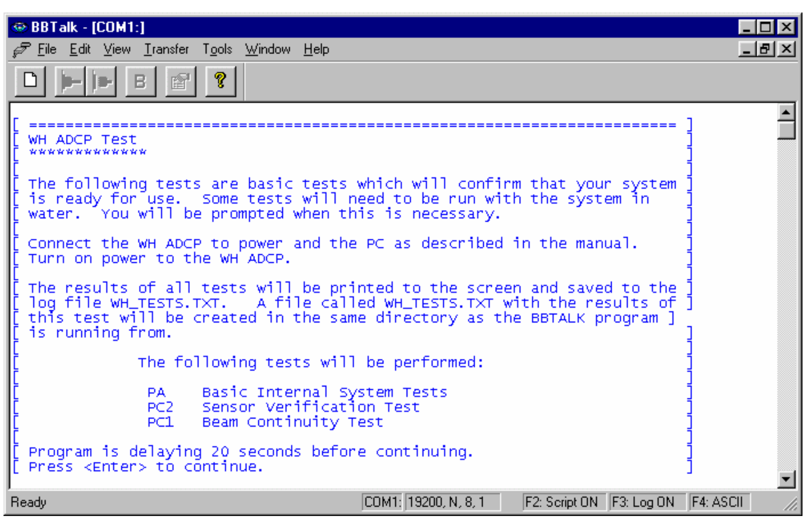


Figure 23. Using BBTalk to Test a Navigator

6.2 Test Results

This section shows an example of the test result printout after running the *BBTalk* script file TestWH.rds.

NOTE. The built-in tests require you to immerse the transducer faces in water. If you do not, some of the tests may fail. Running the tests in air will not harm the DVL (see "Performance and Testing Commands," page 175).

6.2.1 Display System Parameters

This tells the DVL to display specific information about your DVL. For example:

```
>ps0
       Frequency:  307200 HZ
   Configuration:  4 BEAM, JANUS
     Match Layer:  10
      Beam Angle:  20 DEGREES
    Beam Pattern:  CONVEX
     Orientation:  DOWN
       Sensor(s):  HEADING  TILT 1  TILT 2  TEMPERATURE
Temp Sens Offset:  0.00 degrees C

    CPU Firmware:  8.22g Prototype
   Boot Code Ver:  Required:  1.13   Actual:  1.13
    DEMOD #1 Ver:  ad48, Type:  1f
    DEMOD #2 Ver:  ad48, Type:  1f
    PWRTIMG  Ver:  85d3, Type:   7

Board Serial Number Data:
   0F  00 00 00 98 F0 70  09 CPU727-2000-00G
   35  00 00 00 98 F2 AC  09 REC727-1000-06A
   B3  00 00 00 95 10 ED  09 DSP727-2001-06D
   20  00 00 00 B3 50 7B  09 PIO727-3002-06A
   26  00 00 00 C6 D5 FF  09 CAP727-3003-00A
```

Verify the information is consistent with what you know about the setup of your system. If PS0 does *not* list all your sensors, there is a problem with either the communications to the transducer or a problem with the receiver board.

6.2.2 Instrument Transformation Matrix

PS3 sends information about the transducer beams. The Navigator uses this information in its coordinate-transformation calculations; for example, the output may look like this:

```
ps3
Beam Width:   3.7 degrees

Beam     Elevation     Azimuth
  1         -70.14      269.72
  2         -70.10       89.72
  3         -69.99        0.28
  4         -70.01      180.28
```

```
Beam Directional Matrix (Down):
  0.3399    0.0017    0.9405    0.2414
 -0.3405   -0.0017    0.9403    0.2410
 -0.0017   -0.3424    0.9396   -0.2411
  0.0017    0.3420    0.9398   -0.2415

Instrument Transformation Matrix (Down):    Q14:
  1.4691   -1.4705    0.0078   -0.0067       24069  -24092     127    -109
 -0.0068    0.0078   -1.4618    1.4606        -111     127  -23950   23930
  0.2663    0.2657    0.2657    0.2661        4363    4354    4353    4359
  1.0367    1.0350   -1.0359   -1.0374       16985   16957  -16972  -16996
Beam Angle Corrections Are Loaded.
>
```

If the Navigator has beam angle errors, they are reflected in the instrument transformation matrix and the Beam Directional matrix. This matrix, when multiplied by the raw beam data gives currents in the x, y, z, and a data quality indicator named error velocity e.

6.2.3 Pre-deployment Test

This diagnostic test checks the major Navigator modules and signal paths. For example, the output may look like this:

```
>PA
PRE-DEPLOYMENT TESTS
CPU TESTS:
  RTC.....................................PASS
  RAM.....................................PASS
  ROM.....................................PASS
RECORDER TESTS:
  PC Card #0..............................NOT DETECTED
  PC Card #1..............................NOT DETECTED
DSP TESTS:
  Timing RAM..............................PASS
  Demod  RAM..............................PASS
  Demod  REG..............................PASS
  FIFOs...................................PASS
SYSTEM TESTS:
  XILINX Interrupts... IRQ3  IRQ3  IRQ3 ...PASS
  Receive Loop-Back.......................PASS
  Wide Bandwidth..........................PASS
  Narrow Bandwidth........................PASS
  RSSI Filter.............................PASS
  Transmit................................PASS
SENSOR TESTS:
  H/W Operation...........................PASS
```

6.2.4 Display Heading, Pitch, Roll, and Orientation

The PC2 test displays heading, pitch angle, roll angle, up/down orientation and attitude temperature in a repeating loop at approximately 0.5-sec update rate. Any key pressed exits this command and returns the user to the command prompt.

```
Press any key to quit sensor display ...
Heading   Pitch    Roll   Up/Down    Attitude Temp   Ambient Temp  Pressure
301.01°  -7.42°  -0.73°     Up          24.35°C        22.97°C        0.0 kPa
300.87°  -7.60°  -0.95°     Up          24.36°C        22.97°C        0.0 kPa
300.69°  -7.61°  -0.96°     Up          24.35°C        22.98°C        0.0 kPa
300.76°  -7.60°  -0.98°     Up          24.38°C        22.97°C        0.0 kPa
```

6.2.5 Beam Continuity

The PC1 tests the beam continuity by measuring the quiescent Receiver Signal Strength Indicator (RSSI) levels. There must be a change of more than 30 counts when the transducer face is rubbed.

```
BEAM CONTINUITY TEST
When prompted to do so, vigorously rub the selected
beam's face.
If a beam does not PASS the test, send any character to
the DVL to automatically select the next beam.

Collecting Statistical Data...
  52  48  50  43

Rub Beam 1 = PASS
Rub Beam 2 = PASS
Rub Beam 3 = PASS
Rub Beam 4 = PASS
```

6.3 Sea Acceptance Tests

This procedure is intended to test the Navigator at sea. This procedure assumes that the *BBTalk* tests have been run and that all of the items have passed or been confirmed to be operational. The following tests will not obtain favorable results unless all of this work has been performed.

The reason for Sea Acceptance Testing is that although the *BBTalk* Tests confirm the Navigator is operational, they do not confirm that the system is able to perform to its specifications. The performance of any DVL relies greatly upon the installation into any platform. Therefore, the system must be tested at sea to understand the effects of the platform on the DVL performance.

Equipment Required

Navigator 300 kHz, 600 kHz, or 1200 kHz DVL with firmware 9.xx or greater

PD13 Data Output Format line 3 and 9 (see "DVL Output Data Format (PD13)," page 263).

6.3.1 Bottom Tracking Test

The bottom tracking capability of the Navigator varies depending on the type of bottom (hard, soft, rock, sand, etc.), the slope of the bottom, and the speed of the vessel (background noise).

Bottom Tracking Platform Test Setup

The key to this test is to operate the system in an area where both the minimum and maximum bottom tracking range can be obtained. Prior to the test, select the 13th data serial output format by sending 'PD13' to the DVL. The platform will travel over water that is very shallow (<2 meters) to very deep (greater than the maximum bottom track range). It does not matter if the water starts deep and goes shallow or vice-versa.

The platform course for this test is a continuous straight line. The speed of the platform will be varied during this test. The following table lists the recommended speeds.

Table 13: Bottom Track Test Platform Speed

Test #	Speed
Speed 1	Drifting
Speed 2	3 knots = 1.5m.s^{-1}
Speed 3	6 knots = 3m.s^{-1}
Speed 4	9 knots = 4.6m.s^{-1}
Speed 5	12 knots = 6.2m.s^{-1}
Speed 6	Maximum Speed

Speeds can be monitored in lines 8-to-10 based on what coordinate system has been selected (See "EX – Coordinate Transformation," page 170)

How to Determine Bottom Tracking Reasonableness

Viewing the bottom track Altitude data in line 3 from the PD13 output, record the maximum and minimum bottom track depths in the table below.

Beam #	Minimum Depth (meters)						Maximum Depth (meters)					
Speed	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Beam 1												
Beam 2												
Beam 3												
Beam 4												

A pass condition is if the maximum depth of the system is equal to the specification for the nominal bottom track range.

Table 14: Navigator Altitude (Uncertainty±1%)

System Frequency	1200kHz	600kHz	300kHz
Maximum Altitude (m)	30	90	200
Minimum Altitude (m)	0.5	0.7	1.0

7 Troubleshooting

Considering the complexity of the Navigator, we have provided as much information as practical for field repair; *fault location to the component level is beyond the scope of these instructions*. The provided information assumes that faults are isolated with a large degree of certainty to a Least Replaceable Assembly (LRA) level only. The time to repair the system will be minimized if an entire replacement unit is available in the field. If time to repair is of essence, RD Instruments strongly advises the availability of the listed LRAs.

NOTE. When an addition or correction to the manual is needed, an Interim Change Notice (ICN) will be posted to our web site on the Customer Service page (www.rdinstrument.com). Please check our web site often.

Table 15: List of Least Replaceable Assemblies

LRA	Description
DVL	The entire DVL; includes the electronics, housing, and transducer ceramic assemblies.
I/O Cable	Connects the DVL to the Computer.
Housing	Includes the housing, connector, and internal I/O cable.
DVL electronics	The spare boards kit Includes the PIO, CPU, and DSP boards.
PC Card	Replaceable optional PC recorder card.

Since these Least Replaceable Assemblies are manufactured in different configurations, please contact RD Instruments (see "Technical Support," page 107 for contact information) to obtain the correct part number for your specific system configuration. Please provide the serial number of the DVL when contacting RD Instruments about a replacement assembly. If you want to replace the I/O Cable only, then please provide the cable length.

7.1 Equipment Required

Special test equipment is not needed for trouble shooting and fault isolation. The required equipment is listed in Table 16, page 91. Any equipment satisfying the critical specification listed may be used.

Table 16: Required Test Equipment

Required Test Equipment	Critical Specification
DMM	Resolution: 3 ½ digit
	DC-Voltage Range: 200 mV, 2V, 20 V, 200V
	DC-Voltage Accuracy: ± 1%
	AC-Voltage Range: 200 V, 450 V
	AC-Voltage Accuracy: ± 2%
	Resistance Range: 200, 2 k, 20 k, 200 k, 20 MOhm
	Res.-Accuracy: ± 2% @ 200 Ohm to 200 kOhm
	Res.-Accuracy: ± 5% @ 20 Mohm
	Capacitance Range: 20 nF, 2 uF, 20 uF
	Capacitance Accuracy: ± 5%
Serial Data EIA Break-Out Box such as from International Data Sciences, Inc. 475 Jefferson Boulevard Warwick, RI 02886-1317 USA.	Model 60 or similar is recommended as it eases the troubleshooting of RS-232 communication problems significantly. Other manufacturers or models may be substituted.

NOTE. The EIA Break-out Panel is not necessary, but eases RS-232 communication problems troubleshooting significantly.

7.2 Basic Steps in Troubleshooting

The first step in troubleshooting is determining what type of failure is occurring. There are four types of failures:

Communication failure

Built-In test failure

Beam failure

Sensor failure

Communication failures can be the hardest problem to solve as the problem can be in any part of the system (i.e. the computer, Navigator, cable, or power). The symptoms include having the system not respond, or not responding in a recognizable manner (for example "garbled" text).

Built-In test failures will appear when the system diagnostics are run. Use *WinSC* or *BBTalk* to identify the failing test.

Beam failures can be identified when collecting data or during the user-interactive performance tests.

Sensor failures can also be identified when collecting data or during the user-interactive performance tests. The sensor may send incorrect data, or not be identified by the system.

7.3 Troubleshooting the Navigator

Although the Navigator is designed for maximum reliability, it is possible for a fault to occur. This section explains how to troubleshoot and fault isolate problems to the Least Replaceable Assembly level (see Table 15, page 90). Before troubleshooting, review the procedures, figures, and tables in this guide. Also, read the "System Overview," page 6 to understand how the Navigator processes data.

CAUTION. Under all circumstances, follow the safety rules listed in the "Troubleshooting Safety," page 92.

7.3.1 Troubleshooting Safety

Follow all safety rules while troubleshooting.

CAUTION. Servicing instructions are for use by service-trained personnel. To avoid dangerous electric shock, do not perform any service unless qualified to do so.

CAUTION. Complete the ground path. **The power cord and the outlet used must have functional grounds.** Before power is supplied to the Navigator, the protective earth terminal of the instrument must be connected to the protective conductor of the power cord. The power plug must only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.

CAUTION. Any interruption of the earthing (grounding) conductor, inside or outside the instrument, or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury.

CAUTION. Only fuses with the required rated current, voltage, and specified type must be used. Do not repair fuses or short circuit fuse-holders. To do so could cause a shock or fire hazard.

CAUTION. Do not install substitute parts or perform any unauthorized modifications to the instrument.

CAUTION. Measurements described in the manual are performed with power supplied to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury.

CAUTION. Do not attempt to open or service the power supply.

CAUTION. Any maintenance and repair of the opened instrument under voltage should be avoided as much as possible, and when inevitable, should be carried out only by a skilled person who is aware of the hazard involved.

CAUTION. Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

7.4 Troubleshooting a Communication Failure

Navigator DVLs communicate by means of two serial communication channels. The user can choose between RS-232 and RS-422 classes of serial interfaces with a switch on the PIO board in the Navigator.

To successfully communicate, both the host computer and the Navigator must communicate using the same class of serial interface. Standard serial interfaces in IBM compatible computers are also RS-232.

NOTE. If you have just received your Navigator from TRDI, the standard configuration is RS-232.

NOTE. If you are using a high baud rate and/or a long I/O cable (greater then 50 meters) connected to a DVL, RS-232 may not work. Switch to RS-422 and try to wakeup the Navigator again.

There are two types of communication failures; nothing happens at all when attempting to wake up the DVL, or something happens, but not the correct wake up message is displayed.

7.4.1 Baud Rate or Parity Mismatch

When you send a break and the data is garbled, you may have a baud rate or parity mismatch between the Navigator and the computer, or the Navigator may be set for RS-422 instead of RS-232. Check the RS-232/422 switch on the PIO card inside the Navigator. See "Incorrect Wakeup Messages," page 95 for symptoms of garbled wakeup messages.

NOTE. Most communication problems are associated with incorrect cabling (i.e. the serial cable is connected to the wrong port) or data protocols (i.e. the wrong baud rate is set between the Navigator and computer).

7.4.2 COM info in the Wakeup Message

When you send a break the text inside the brackets '[…]' of the first line of the Wakeup Messages indicates the DVL communication configuration:

`[BREAK Wakeup A]` => DVL is set to send/receive RS232 communication through the serial lines of the I/O cable

`[BREAK Wakeup B]` => DVL is set to send/receive RS422 communication through the serial lines of the I/O cable.

`[BREAK Wakeup AB]` => RS232/422 switch on the top of the PIO board in the DVL is in between two positions, but neither RS232 nor RS422. It can also mean that the DVL received a trigger pulse while in command mode.

7.4.3 Alarm Wakeup Message

When you send a break, if the battery has a low voltage reading you will get the following message:

```
[ALARM Wakeup A]
Navigator Broadband ADCP Version 9.20
RD Instruments (c) 1996-2005
All Rights Reserved.
>
```

CAUTION. If this message appears after a break, it is advised not to deploy the DVL since we cannot guarantee the unit will perform to the performance specifications.

7.4.4 Nothing Happens

If you cannot talk to the Navigator (i.e., no wakeup message at all), you need to isolate the problem to a computer fault, power, cable failure, or a Navigator problem. Check the following items:

a. Connect the Navigator to a computer according to "Setup the Navigator," page 11. Check that all cable connections are tight.

b. Is the AC power adapter working? Is the input voltage between 100 to 240 VAC? Is the output level 48 VDC?

c. If the Navigator is running from a battery, check that the battery voltage is above 30 Volts DC. Navigator DVLs will work at 20 volts; however, both lithium and alkaline battery packs with voltages below 30 volts are at or near their end of life, and are approaching uselessness.

d. Is the computer hooked up properly? Does it have power?

e. Make sure that your computer and the *BBTalk* program are set up to use the communication port the I/O cable is connected to on the computer.

7.4.5 Incorrect Wakeup Messages

The following conditions may indicate a communications mismatch or lost boot code.

Sending a break causes “garbage” to appear on the screen. The “garbage” text may keep scrolling. This happens when the computer is using RS-232 and the DVL is set for RS-422 or vice-versa. Check the RS-232/RS-422 switch on the PIO board (see “Communications Setting,” page 69).

Sending a break causes “garbage” to appear on the screen. You can hear the DVL “beep” when the break is sent. The “garbage” text does not keep scrolling. Check that the DVL and computer are both using the same baud rate. See “CB - Serial Port Control,” page 153 for details.

If the DVL gives a steady “beep” when power is applied, the “>” prompt appears on the screen, and a “X” appears when additional breaks are sent, this may indicate that the boot code has been lost (see “DVL Checks,” page 96). This can happen if you abort while downloading new firmware. Try downloading the firmware again.

7.4.6 Check the Power

The following test can be done with a voltmeter to check the power. Check the power going into the DVL by measuring the voltage on the end of the cable that connects to the Navigator at Pins 3 and 7 (GND) (see “Navigator Cables,” page 108). The voltage should be +48 VDC (using the standard AC adapter). If not, check the voltage at the other end of the cable and the AC adapter.

7.4.7 Check the I/O Cable

This test will check the communication between the computer and the Navigator.

a. Disconnect both ends of the cable and measure the continuity using a DMM (see “Navigator Cables,” page 108 for the wiring diagram). Correct any problems found.

d. Reconnect the I/O cable to host computer.

a. Load *BBTalk* on your computer. Select the proper communications port (see the RDI Tools User's Guide for help on using *BBTalk*).

b. For RS-232 communications, short pins 1 and 2 together on the female 7-pin connector that was plugged into the Navigator (see “Navigator Cables,” page 108). If you are using RS-422, connect a jumper between pin 2 to pin 6 and another jumper between pins 1 to pin 5 of the underwater connector at the Navigator end of the cable.

c. Type any characters on the keyboard. The keys you type should be echoed on the screen. If you see characters, but not correctly (garbage), the cable may be too long for the baud rate. Try a lower baud rate. If this works disconnect the jumper on pins 1 and 2 and then push any keys on the keyboard. You should NOT see anything you type.

d. If the keys are echoed correctly on the screen, the computer and the communication cable are good. Re-connect the I/O cable to the Navigator. The above loop-back test does not show if transmit and receive pairs are interchanged. Thus, it is important that you check the wiring diagrams provided in “Navigator Cables,” page 108.

NOTE. A loop-back test does not show if transmit and receive wires or pairs are interchanged, even though characters may be displayed correctly.

7.4.8 DVL Checks

Once you have eliminated possible problems with the power, I/O cable, communications settings, and the computer, that leaves the DVL as the source of the problem. The following checks may help in some situations.

Cold Start the DVL

a. Remove the housing to gain access to the PC boards.

b. Remove *all* power to the DVL.

CAUTION. Disconnect the power cables P1 and P2 on the PIO board to ensure that NO POWER is applied to the DVL during the next step.

c. Short TP10 to TP11 on the PIO board for 10 seconds.

d. Remove the jumper.

e. Connect the computer and connect power to the DVL. Send a break to the DVL. This should start the DVL in the “cold start” mode.

Fuse

Check the fuse on the PIO board is not blown (see “Fuse Replacement,” page 68 for fuse replacement procedures).

CAUTION. Only fuses with the required rated current, voltage, and specified type must be used. Do not repair fuses or short circuit fuse-holders. To do so could cause a shock or fire hazard.

Boot Code Error

If the DVL gives a steady “beep” when power is applied, the “>” prompt appears on the screen, and an “X” appears when additional breaks are sent, this may indicate that the boot code has been lost. This can happen if you abort while downloading new firmware. Try downloading the firmware again.

7.5 Troubleshooting a Built-In Test Failure

The built-in diagnostic tests check the major DVL modules and signal paths. The spare boards kit may be used to repair some failures. This kit includes:

Spare Boards including PIO board, CPU board, and DSP board. These boards are held together with the standard M4 screw assembly and kept inside a protective anti-static bag.

A disk containing your original beam cosine matrix table

Tools for installation

NOTE. The Spare Boards kit is not included with the system. You can order the kit by contacting RD Instruments Customer Service department (see “Technical Support,” page 107).

7.5.1 When to use the Spare Boards Kit

Use this Kit whenever you have any of the following problems:

Cannot communicate to the Navigator and you have ensured that the serial port on the computer, Navigator Cable, and Navigator RS-232 to RS-422 converter (if used) are all working properly.

Your Navigator fails any of the following PA tests at any time:

CPU Tests:
RTC
RAM
ROM

DSP Tests:
Timing RAM
Demod RAM
Demod REG
FIFOs

System Tests:
XILINK Interrupts
Receive Loop Back Test

Your Navigator fails any of the following PA tests provided the items indicated by {} have been checked:

Recorder Tests:

Any recorder tests fails {provided that the PCMCIA card(s) have been checked for proper installation, operation and they are DOS formatted; we STRONGLY recommend checking PCMCIA cards in a computer before replacing the boards}

System Tests:

Transmit {if the Navigator fails when it is in water and air bubbles have been rubbed from the faces}

Sensor Tests:

H/W Operation {if the Navigator fails when it is NOT sitting/resting on its side, or located near a large magnetic field like a motor in a boat}

The spare boards kit will not correct any of the following failures:

A damaged beam or its urethane surface

Damage to the transducer beam connections below the copper shield

If it passes all PA tests and yet the data is all marked as bad

Fails the following PA test:

System Tests:

Wide Bandwidth {bandwidth tests may fail due to external interference}

Narrow Bandwidth {bandwidth tests may fail due to external interference}

RSSI Filter

Transmit

Table 17: Pre-deployment Test (PA) Possible Cause of Failures

PA Test Name	Possible Cause of Failure
Pre-Deployment Tests CPU Tests: RTC RAM ROM	CPU board failed
Recorder Tests: PC Card #0 Card Detect Communication DOS Structure Sector Test (short) PC Card #1 Card Detect Communication DOS Structure Sector Test (short)	PC card not plugged in PC card failed DSP board failed
DSP Tests: Timing RAM Demod RAM Demod REG FIFOs	DSP board failed
System Tests: XILINX Interrupts	DSP or CPU board failed
Receive Loop-Back	DSP or CPU board failed
Wide Bandwidth	Not in water External interference DSP or Receiver board failed
Narrow Bandwidth	
RSSI Filter	
Transmit	Not in water or PIO board failed
Sensor Tests: H/W Operation	PIO board failed Receiver board failed Pressure sensor failed DVL laying on its' side

7.5.2 Installation of the Spare Board Kit

This Kit has been setup so that you will replace all three of the Navigator boards at once. This is done so that you do not have to risk damaging the individual boards while swapping in individual boards. The heading, pitch, and roll sensors have all been calibrated (the temperature sensor is an independent calibration and not changed by these new boards). Once you have replaced your original boards, place them back in the Spare Board Kit box and contact RD Instruments Customer Service Department so that you can return them for repair (see "Technical Support," page 107).

CAUTION. Before handling either the Spare Board Kit or the original Board Set, always wear an earth-grounding static protection strap. The electronics in the Navigator are very sensitive to static discharge. Static discharge can cause damage that will not be seen immediately and will result in early failure of electronic components.

We assume that a qualified technician or equivalent will perform all of the following work.

The Spare Boards Set will allow your system to perform to the same velocity specifications as your original set. There is, however, an offset error in the compass that can be as great as ±1.5 degrees. This error CANNOT be removed by doing the Field Calibration procedure (AF command) even though you MUST do this as part of the installation. The additional ±1.5 degrees can only be removed by TRDI at the factory.

However, in most cases, the total compass error will still be within our original specification of ±5.0 degrees. The only way to be sure that you have smaller errors than this specification is to perform your own local compass verification and correct any errors you find during your post processing of the data.

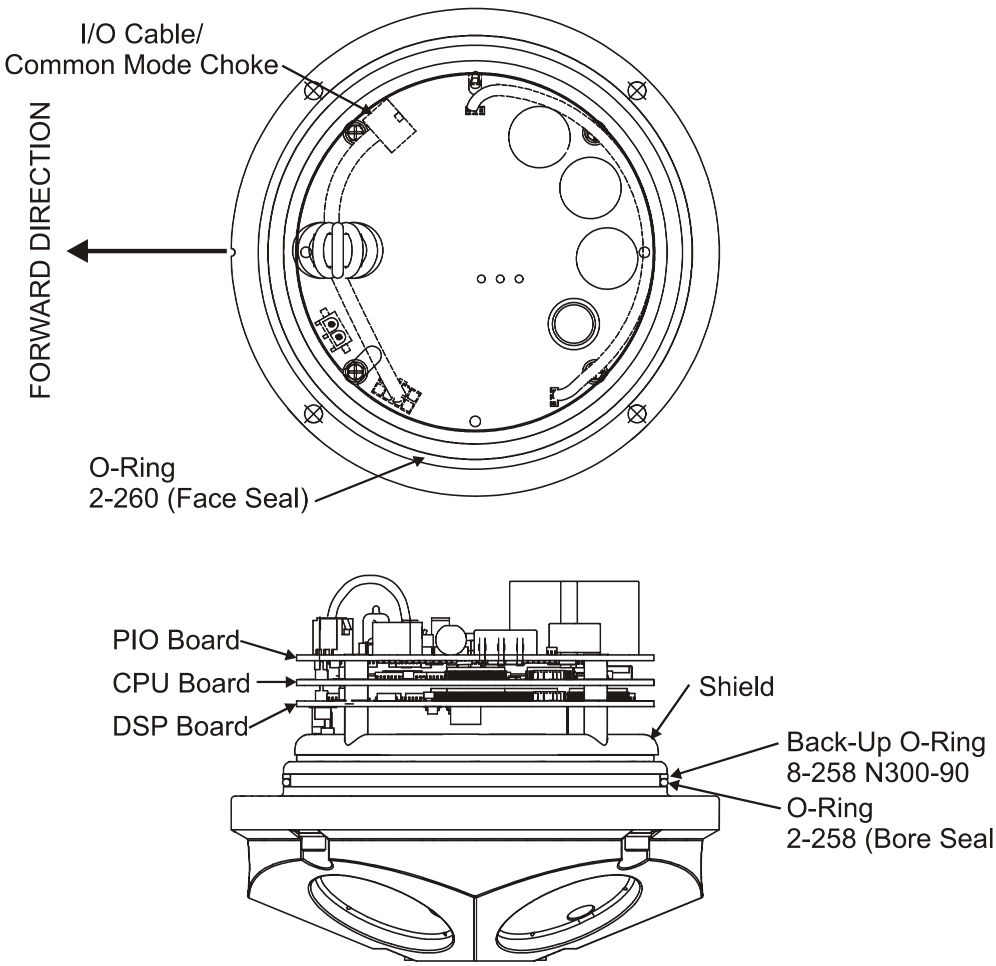


Figure 24. Navigator Board Locations

7.5.3 Remove the Original Set of Boards

a. Remove the Transducer assembly from the pressure case. Use "Navigator Disassembly," page 59 for instructions.

b. With your earth-ground static protection strap on, use a 3mm Allen wrench, to remove the four bolts that secure the three original Navigator boards to the Transducer assembly.

c. Note the orientation of the transmit cable connector as it is plugged into the PIO board and to the Receiver board (see Figure 25).

This cable must be removed and it has a very tight fit. To remove this cable, lift straight up on the three boards and tilt slightly (no more than 2 cm) toward the cable. This should allow you enough slack to unplug the cable from the PIO board. If this is not possible you may unplug the cable from the Receiver board. Be sure to note its orientation before unplugging.

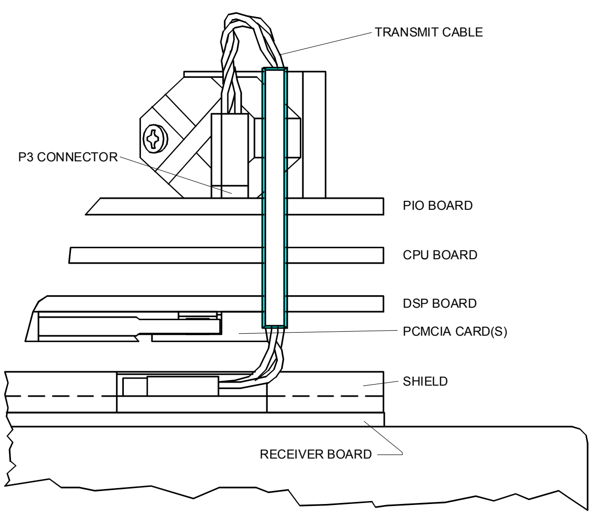


Figure 25. Transmit Cable

d. Once the transmit cable has been disconnected you may now remove the top three boards as a set by lifting the set straight up.

These top three boards are connected to each other via connectors and will remain as one piece (see Figure 26, page 102). The DSP board connects to the Receiver board through a 26-pin header. The 26-pin header is a series of male pins. The 26-pin header may or may not stay connected to the DSP board when you remove the top three boards. If you see that there are male pins sticking out of the DSP board when you finish removing the board set then the header has remained attached to the DSP board. If this happens remove it and place it into the Receiver board. To remove it, gently rock it back and forth while pulling it away from the DSP board. Once removed, align it with the connector on the Receiver board and press it into place.

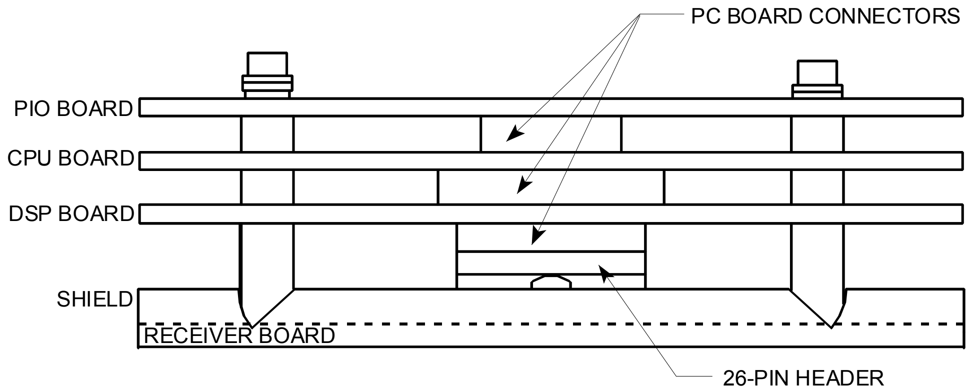


Figure 26. PC Board Connectors

e. Remove all PCMCIA card(s) from the original set of boards. These PCMCIA cards will be used again once you install your Spare Boards Set. The Spare Board set does NOT contain a PCMCIA card(s). The PCMCIA card(s) are located on the bottom of the DSP board. To remove the PCMCIA card(s) press the button(s) on the side of the PCMCIA card slot. As you press this button the PCMCIA card will slide out. You will have to pull the card(s) out the rest of the way once the button is depressed all the way in.

f. Set the original board set to the side for now.

7.5.4 Installing the Spare Board Kit

a. With your earth-ground static protection strap on, remove the Spare Board Kit from the anti-static bag.

b. Using a 3 mm Allen wrench and a 7mm wrench remove the nuts from the bolts that secure the Spare Boards together. You will be using these bolts to secure the spare set in your system. DO NOT change the position of any of the bolts. The bolt containing the felt washers and ground jumper must remain in the same position (see Figure 27, page 103).

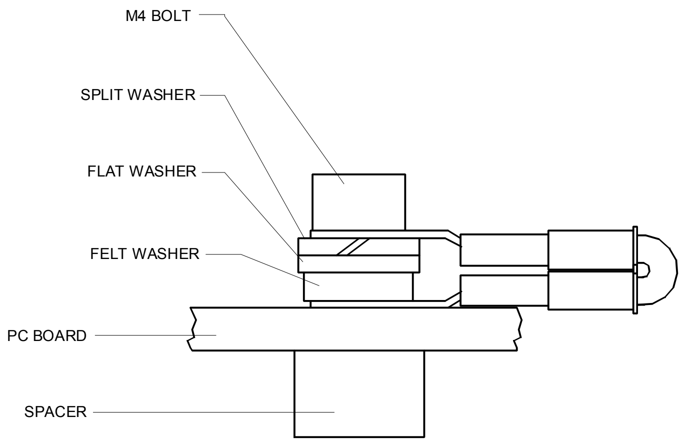


Figure 27. Ground Jumper

c. Place the nuts (just removed) on the four bolts of your original set of boards and place them into the anti-static bag. You will use the new set of bolts included in the Spare Board kit to secure them to the Transducer assembly.

d. Install all PCMCIA cards removed in "Remove the Original Set of Boards," page 101 step e into the PCMCIA card slots. The PCMCIA card is keyed and will only connect when it has been aligned correctly and slid all the way in. The PCMCIA card is installed with the label side pointing away from the DSP board.

e. Connect the Spare Board set to the Receiver board. Align the Spare Board set to the 26-pin header connected to the Receiver board. As you connect the Spare Board set, connect the transmit cable you removed in "Remove the Original Set of Boards," page 101 step c. Be sure to connect the cable in the same orientation as was installed on the original board set.

   To test that the transmit cable is connected properly, start *BBTalk* and run the PT4 test. The test failure example shown below is what you would see for a missing or improperly attached transmit cable.

```
[BREAK Wakeup A]
Navigator Broadband DVL Version 16.21
RD Instruments (c) 1996-2002
All Rights Reserved.
>pt4

IXMT    =      0.0 Amps rms  [Data= 0h]
VXMT    =     19.3 Volts rms [Data=4ch]
   Z    =    999.9 Ohms
Transmit Test Results = $C0 ... FAIL
>
```

f. Insert the four new bolts and tighten to 4 Newton-pounds.

g. Install the housing (see "Navigator Re-assembly," page 59).

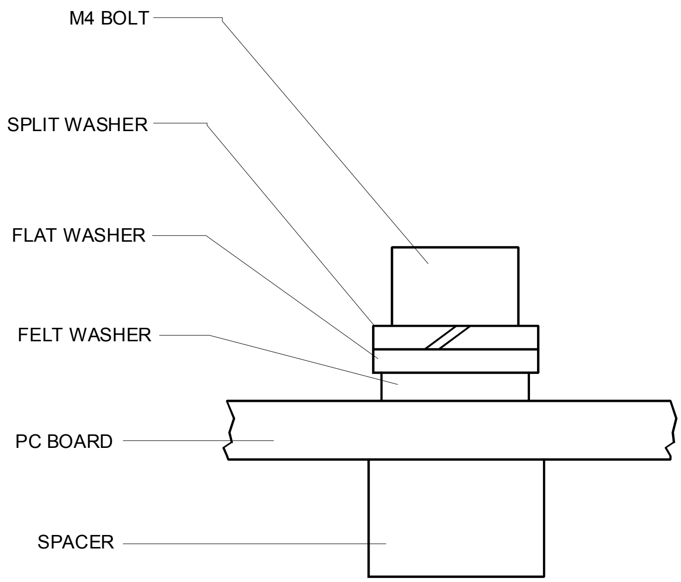


Figure 28. Mounting Hardware

7.5.5 Installing the Beam Cosine Matrix

The beam cosine matrix table corrects small transducer beam misalignment angles that occur during manufacturing.

a. Connect your Navigator DVL as you would normally and apply power.

b. Start *BBTalk* and confirm that the Navigator DVL is communicating normally and what communications port you are using (COM 1 or COM 2).

c. Place the Beam Cosine Matrix Disk into your computer's disk drive.

d. If your DVL is connected to COM 1, press **<F2>** and run the script file *xxxx_1.scr* (where xxxx is your system serial number).

   If your DVL is connected to COM 2, press **<F2>** and run the script file *xxxx_2.scr* (where xxxx is your system serial number).

   Your Beam Cosine Matrix table will automatically be updated in your DVL and a file called SPRBD.LOG will be created. You can view the contents of this file to confirm that the data entered during the &V portion matches the contents in the PS3 results under the label Q14.

7.5.6 Testing the System

a. Install the Transducer in the Pressure Case.

b. Connect the cable and power as you normally do and test as DVL as shown in "Testing the Navigator," page 85. All PA tests should pass when run in water and the PC tests should pass out of water.

c. ***Perform a field calibration of your compass***. Use “Compass Calibration,” page 64 for instructions on running the AF command. Remember that there will be up to 1.5 degrees of offset error in the compass measurement. This error is not removed by the field calibration.

You have completed the Navigator Spare Board Installation. The original boards can be returned to TRDI for repair. Please contact the RD Instruments Customer Service Department for return shipping instructions and repair costs at:

EMAIL: rdifs@rdinstruments.com

PHONE: 858-693-1178

FAX: 858-578-4016

7.6 Troubleshooting a Beam Failure

If the beam continuity test fails, a bad DSP board, Receiver board, PIO board, or a bad beam may cause the failure. If replacing the DSP and PIO board (included with the spare boards kit) does not fix the problem, the DVL must be returned to TRDI for repair.

```
>PC1

BEAM CONTINUITY TEST

When prompted to do so, vigorously rub the selected
beam's face.

If a beam does not PASS the test, send any character to
the DVL to automatically select the next beam.

Collecting Statistical Data...
  41  46  45  43  41  46  45  43  41  46  45  42  41  46  44  42

Rub Beam 1 = PASS |   NOTE - Possible cause of failure
Rub Beam 2 = PASS |          DSP Board
Rub Beam 3 = PASS |          Receiver Board
Rub Beam 4 = PASS |          PIO Board
>                 |          Beam
```

7.7 Troubleshooting a Sensor Failure

If the PA test fails the sensor test, run PC2 to isolate the problem. The ambient temperature sensor is mounted on the receiver board. This sensor is imbedded in the transducer head, and is used for water temperature reading. The attitude temperature sensor is located on the PIO board under the compass. The DVL will use the attitude temperature if the ambient temperature sensor fails.

If one of the temperature sensors fails, the PC2 test will show both sensors at the same value.

```
>PC2
Press any key to quit sensor display ...

Heading   Pitch    Roll   Up/Down    Attitude Temp   Ambient Temp   Pressure
301.01°  -7.42°  -0.73°     Up          24.35°C        22.97°C        0.0 kPa
300.87°  -7.60°  -0.95°     Up          24.36°C        22.97°C        0.0 kPa
300.95°  -7.60°  -0.99°     Up          24.37°C        22.97°C        0.0 kPa
300.71°  -7.61°  -0.96°     Up          24.37°C        22.98°C        0.0 kPa
300.69°  -7.61°  -0.96°     Up          24.35°C        22.98°C        0.0 kPa
300.76°  -7.60°  -0.98°     Up          24.38°C        22.97°C        0.0 kPa
>
```

NOTE. If the temperature sensor is bad, the data can still be collected with no effects to accuracy or quality. Contact TRDI about scheduling a repair of the temperature sensor at your convenience (see "Technical Support," page 107).

7.7.1 Fault Log

To determine why a sensor failed, view the fault log. To view the fault log, start *BBTalk*. Press the **End** key to wakeup the DVL. Type the following commands: **CR1**, **FC**, **PA**, **FD**. The fault log will be displayed by the FD-command.

```
[BREAK Wakeup A]

Navigator Broadband DVL Version x.xx
RD Instruments (c) 1996-1997
All rights reserved.
>CR1
>FC
>PA
|          (PA test results (not shown))
|
>FD
Total Unique Faults   =     2
Overflow Count        =     0
Time of first fault:   97/11/05,11:01:57.70
Time of last fault:    97/11/05,11:01:57.70

Fault Log:
Entry #  0 Code=0a08h  Count=    1  Delta=    0 Time=97/11/05,11:01:57.70
 Parameter = 00000000h
  Tilt axis X over range.
Entry #  1 Code=0a16h  Count=    1  Delta=    0 Time=97/11/05,11:01:57.70
 Parameter = 00000000h
  Tilt Y axis ADC under range.
End of fault log.
```

7.8 Technical Support

If you have technical problems with your instrument, contact our field service group in any of the following ways:

Teledyne RD Instruments	**Teledyne RD Instruments Europe**
14020 Stowe Drive	5 Avenue Hector Pintus
Poway, California 92064	06610 La Gaude, France
(858) 842-2600	+33(0) 492-110-930
FAX (858) 842-2822	+33(0) 492-110-931
Sales – rdisales@teledyne.com	rdie@teledyne.com
Field Service - rdifs@teledyne.com	rdiefs@teledyne.com

Web: http://www.rdinstruments.com
http://www.dvlnav.com

If your instrument works and you have questions involving a specific application, you may call either the field service group (above) or our sales / marketing staff.

NOTE. When the TRDI-US and TRDI-Europe offices are closed, customers may now call +1 858-842-2700 to have their after-hours emergencies resolved.

7.9 Navigator Cables

This section has information on Navigator cabling. Special user-requests may cause changes to the basic wiring system and may not be shown here. We provide these drawings only as a guide in troubleshooting the DVL. If you feel there is a conflict, contact TRDI for specific information about your system. The following figures show various Navigator cable locations, connectors, and pin-outs.

NOTE. Where shown, the color code is for reference only; your cable may be different.

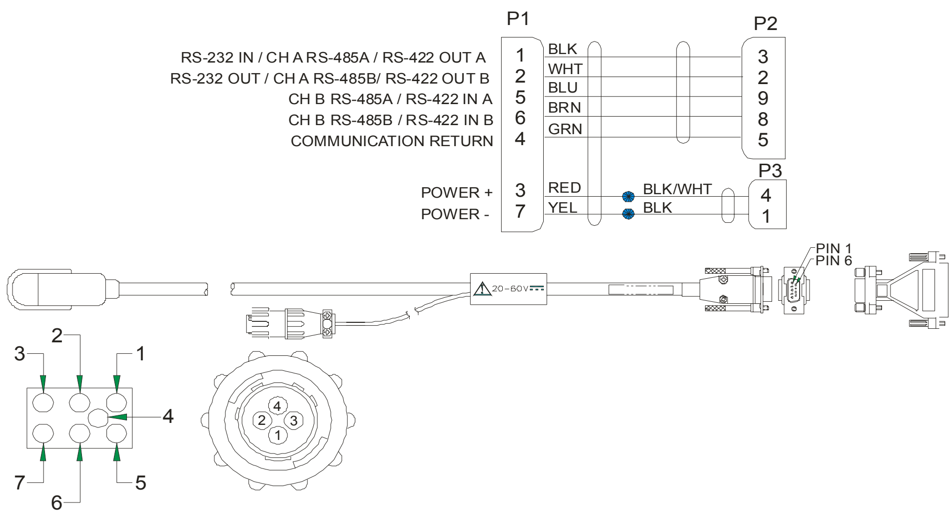


Figure 29. I/O Cable Wiring

NOTE. Where shown, IN refers to signals going into the DVL and OUT refers to signals coming out of the DVL.

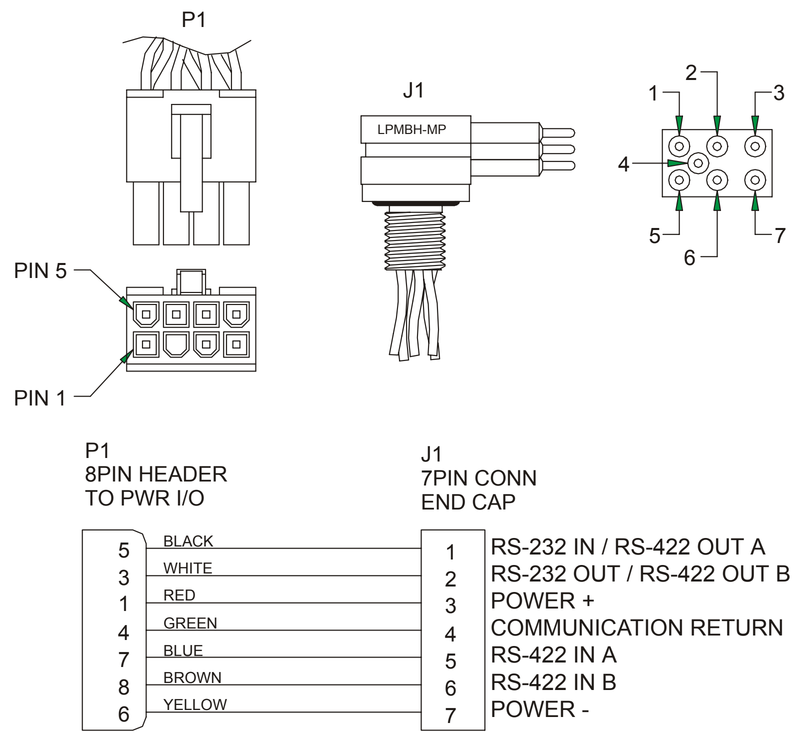


Figure 30. Internal I/O Cable (End-Cap to PIO Board) Wiring

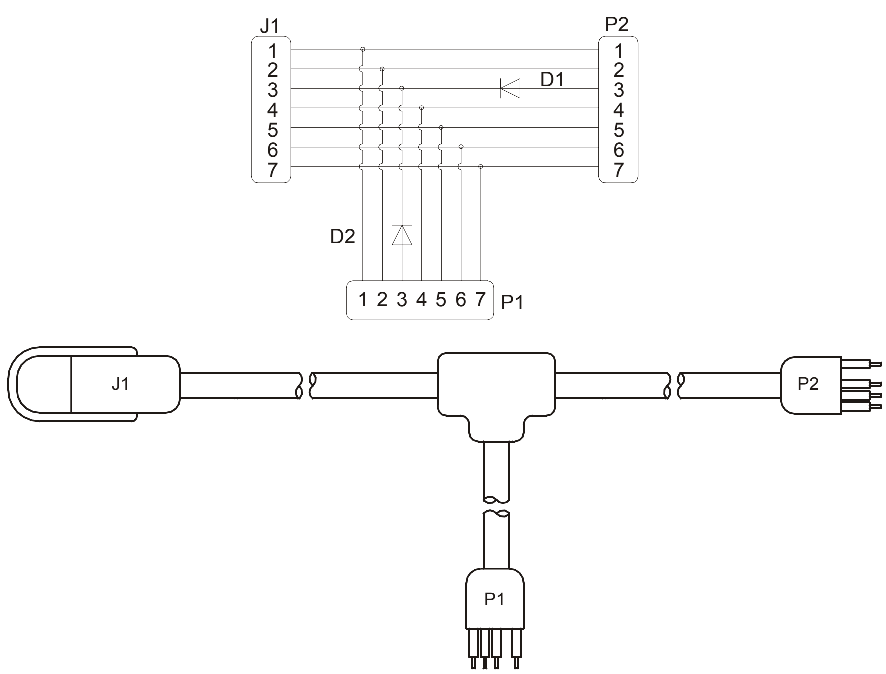


Figure 31. External Battery Pack “Y” Cable

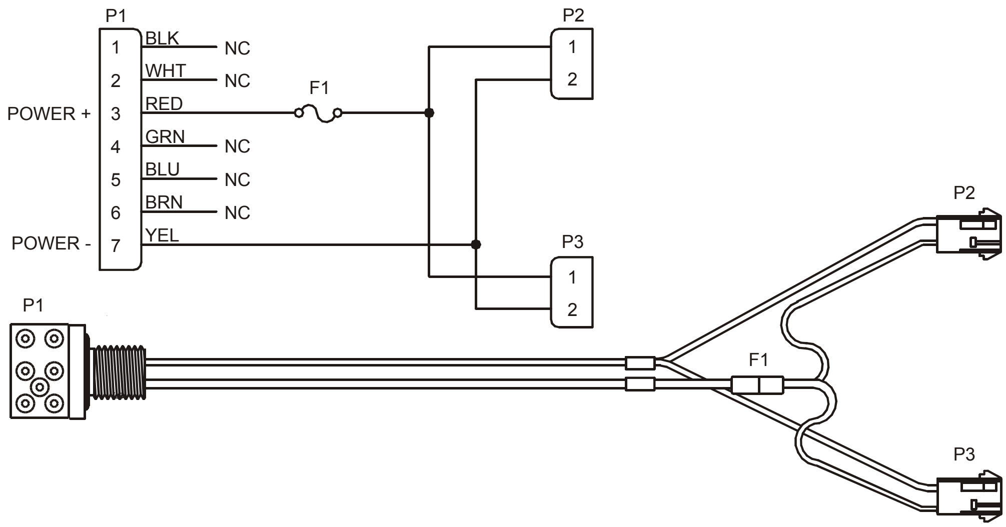


Figure 32. External Battery Case Internal Wiring

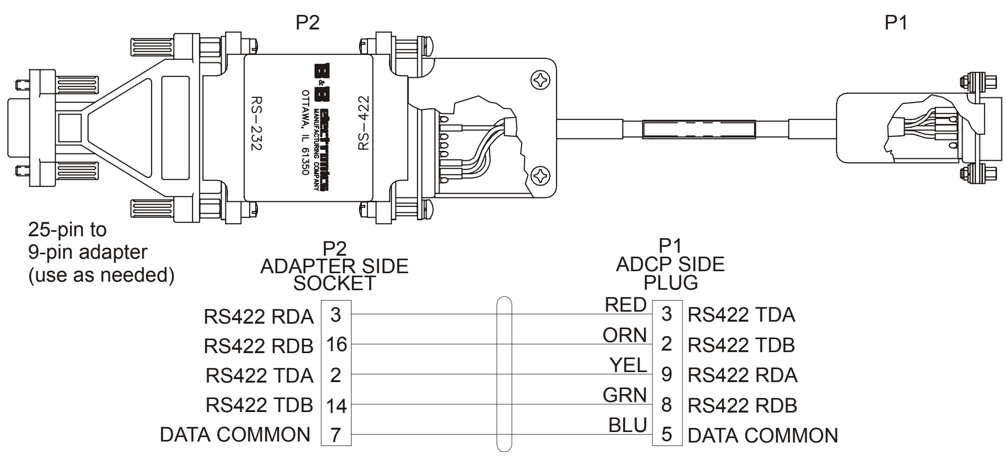


Figure 33. RS232-to-RS422 Converter Wiring (25-Pin to 9-Pin)

7.10 System Overview

This section presents a functional description of Navigator operation using block diagrams.

7.10.1 Operating Modes

The Navigator has two modes of operation: *command mode*, and *turnkey mode*. Depending on what mode the DVL is in; it will go either to sleep or resume pinging.

Command Mode

Whenever you wake up your Navigator, power dissipation increases from less than 1 mW to around 2.2 W. If you leave the Navigator in command mode without sending a command for more than 5 minutes, the Navigator automatically goes to sleep. This protects you from inadvertently depleting batteries.

If the DVL receives a BREAK, it will go to the command prompt and wait for a command. The DVL will wait at the command prompt for five minutes. If no commands have been sent, it will go to sleep (also called "Battery Saver" mode).

If you press the reset switch (located on the CPU board), the DVL will go to sleep.

If the DVL receives a CS-command, it will go into the ping mode and begin pinging. If a TF-command (Time of First Ping) was sent prior to the CS-command, then the DVL will go to sleep until the TF time occurs.

If the DVL does a COLD wakeup (i.e. an unknown state), it will go to the command prompt.

If the DVL is asleep for approximately nine hours, it wakes up to charge the capacitor used to maintain RAM. Once the capacitor is charged (this only takes a few seconds), the DVL goes back to sleep.

Turnkey Mode

Setting the CT command to CT1 lets the Navigator automatically initialize to a predefined command set during any power up.

To place the Navigator in turnkey mode, you must first set all other commands to the desired configuration. You must then send the CT1 and CK commands to save this configuration. When power is cycled, the Navigator will start up with the desired configuration and begin the data collection process. You can interrupt (not remove) this mode by sending a <BREAK>. This will place the Navigator in the command mode, ready to accept inputs. Cycling the power, however, will again start the data collection process.

To turn off the turnkey mode, first send a <BREAK> to the Navigator. Now send the CT0 and CK commands to save this configuration. When power is cycled, the Navigator will NOT begin the data collection process.

7.10.2 Overview of Normal Navigator Operation

Refer to Figure 34, page 115 through Figure 36, page 117. The following events occur during a typical data collection cycle.

a. The user or a controlling software program sends data collection parameters to the Navigator. The user/program then sends a CS-command to start the data collection cycle. The firmware program stored in the CPU microprocessor takes control of Navigator operation based on the commands received through the serial I/O cable.

   Figure 34, page 115 shows a flow chart of the wake-up logic used by the Navigator. The Navigator determines what to do based on where the wake-up came from (a Break, CS-command, battery saver timer, or watchdog timer was detected).

b. On the PIO Board, the POWER REGULATOR circuit sends a transmit command to the POWER AMPLIFIER circuit. This tells the Navigator to start acoustic transmissions (pinging) on all TRANSDUCERS.

c. The TRANSDUCERS receive echoes from the backscatter. The RECEIVER board amplifies and translates the echoes into a base-band frequency.

d. The CPU board processes the received echoes.

e. After echo reception, the Navigator injects a self-test signal into the RECEIVER board and processes the signal as normal data for test purposes.

f. The THERMISTOR measures water temperature at the transducer head and sends it to the CPU via the DSP Board.

g. The PIO Board sends pitch and roll from the TILT SENSOR and Navigator heading from the COMPASS to the DSP Board. The DSP Board digitizes this information and sends it to the CPU for processing.

h. The CPU repeats steps "b" through "g" for a user-defined number of pings. The CPU averages the data from each ping to produce an ensemble data set.

i. At the end of the ensemble (sampling) interval, the CPU sends the collected data to the serial I/O connector or PCMCIA recorder.

7.10.3 Functional Description of Operation

The following paragraphs describe how the Navigator operates and interacts with its modules. Refer to Figure 35, page 116 through Figure 36, page 117 throughout this description.

Input Power

The Navigator requires a DC supply between 20 volts and 50 volts. Either an external DC power supply or external battery packs can provide this power. Figure 35, page 116 shows the DC voltage power distribution path.

With an external supply, power is applied to pins 3 (positive) and 7 (negative) on the external connector (see Figure 35, page 116). The power then goes through an electromagnetic interference (EMI) filter on the PIO Board. This filter reduces the chance that external noise sources associated with the external power source can disrupt Navigator operation.

Board Descriptions

PIO Board.

Receives the filtered/internal power.

Uses a diode "OR" gate to determine which power source to use (external or internal). With both sources connected, the OR gate selects the "higher" voltage for Navigator use.

Limits the in-rush of current to the Navigator and provides over- and negative-voltage protection. Either condition will blow a protective fuse. However, damage could occur to other circuits before the fuse blows. Please ensure you apply only voltages within the specified range (+20 to +50 VDC).

Converts the operating power supply (filtered/isolated 20 to 50 VDC or 5 to 18 VDC) in a DC-to-DC converter to the +5 VDC (Vcc) used to power all other Navigator circuits.

Uses the Power Amplifier circuit on the PIO board to generate the high-amplitude pulse AC signal that drives the sonar transducers. The Power Amplifier sends the drive signal to the Receiver Board.

RS-232/RS-422 switch.

CPU Board.

Real time clock.

Generates most of the timing and logic signals used by the Navigator.

DSP Board.

Contains the PCMCIA recorder slots.

Analog to Digital converter.

Digitizes information from sensors and sends sensor information to the CPU.

Receiver Board.

Tuning functions

Receiver functions

Temperature sensor

Interface for pressure sensor

Sensors

This section describes the standard Navigator sensors. The PIO and DSP boards control the environmental sensors and contain unit-specific data. Sensors include:

Temperature Sensor (Thermistor) - Used to measure the water temperature. The system uses this data to calculate the speed of sound. This sensor is embedded in the transducer head and is not field replaceable.

Up/Down Sensor - Determines whether the transducer head is facing up or down. This sensor is located on the PIO board.

Compass - Determines the Beam 3 heading angle of the Navigator using a flux-gate compass. This sensor is located on the PIO board. The flux-gate measured earth magnetic field vector together with the tilt sensor pitch and roll information is used to determine the heading. Since the tilt sensor data is only valid when the DVL is ±20° from vertical, the heading information is also limited to this range.

Attitude Sensor - Determines the tilt angles of the Navigator. This sensor is located on the PIO board. The attitude sensor uses a pitch and roll liquid-filled sensor. This sensor is functional to an angle of ±20° from vertical.

Pressure Sensor (optional) - Measures pressure at the Navigator transducer. This sensor is embedded in the transducer head and is not field replaceable.

The CPU microprocessor controls a multiplexed analog-to-digital converter to accept analog data from the sensors. Digital data are taken in directly. The pressure sensor incorporates a Wheatstone Bridge strain gage to measure the water pressure at the transducer faces. Depth is calculated from pressure, with water density adjusted by the salinity (ES) setting.

Calibration data for the sensors, a beam-angle correction matrix, and unit identification parameters (frequency, serial number, firmware version, etc.) are stored in ROM.

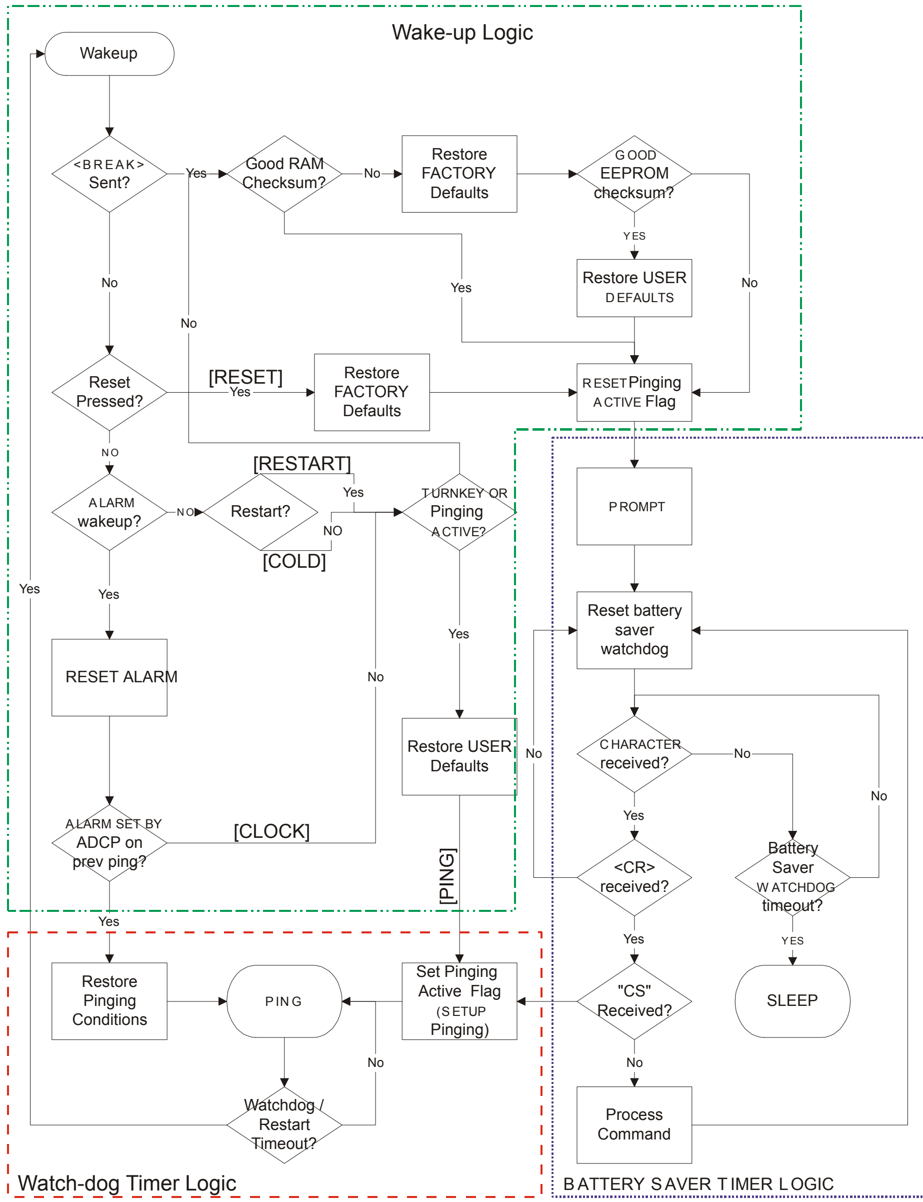


Figure 34. Navigator Wake-up and Timer Logic

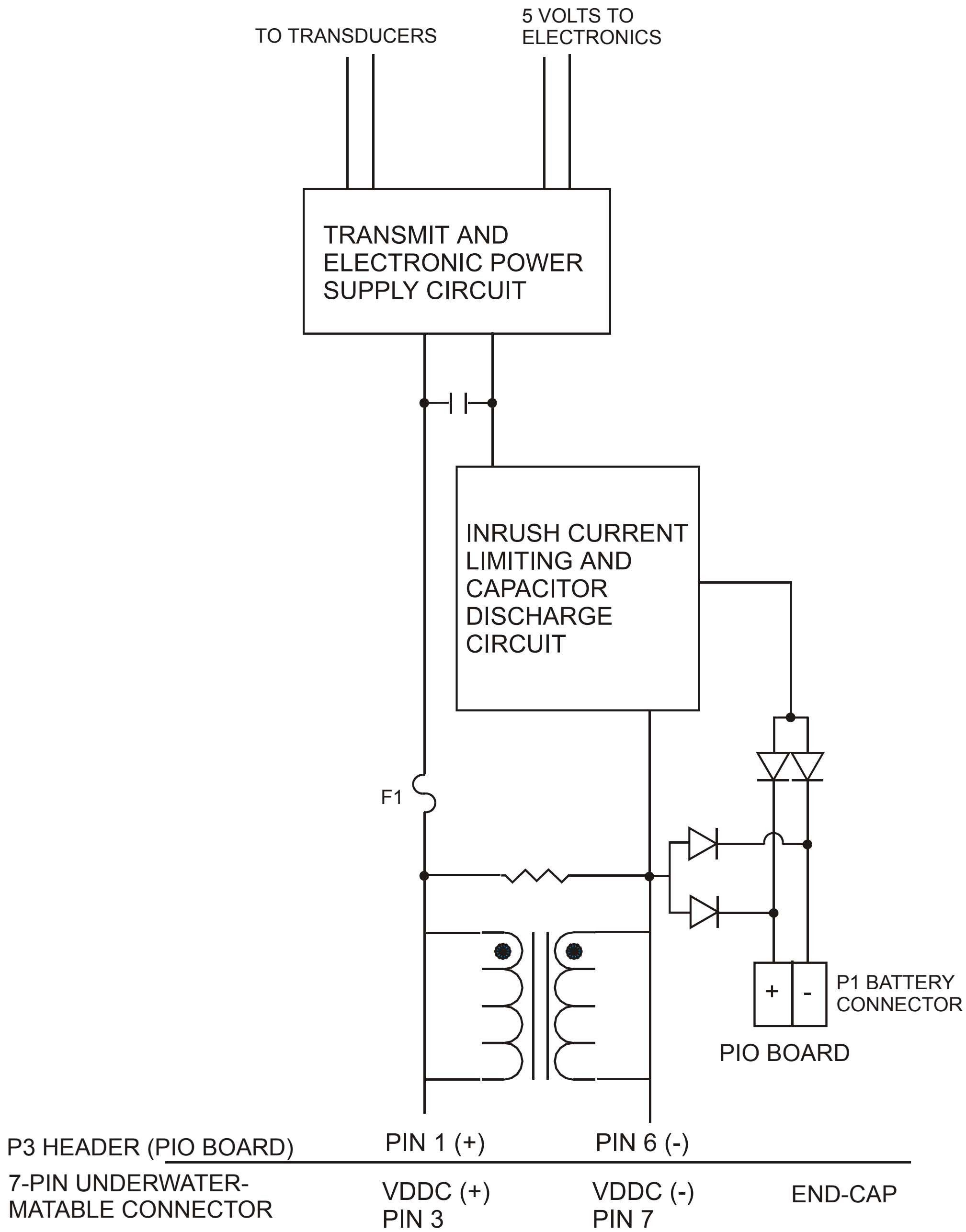


Figure 35. Navigator DC Power Path

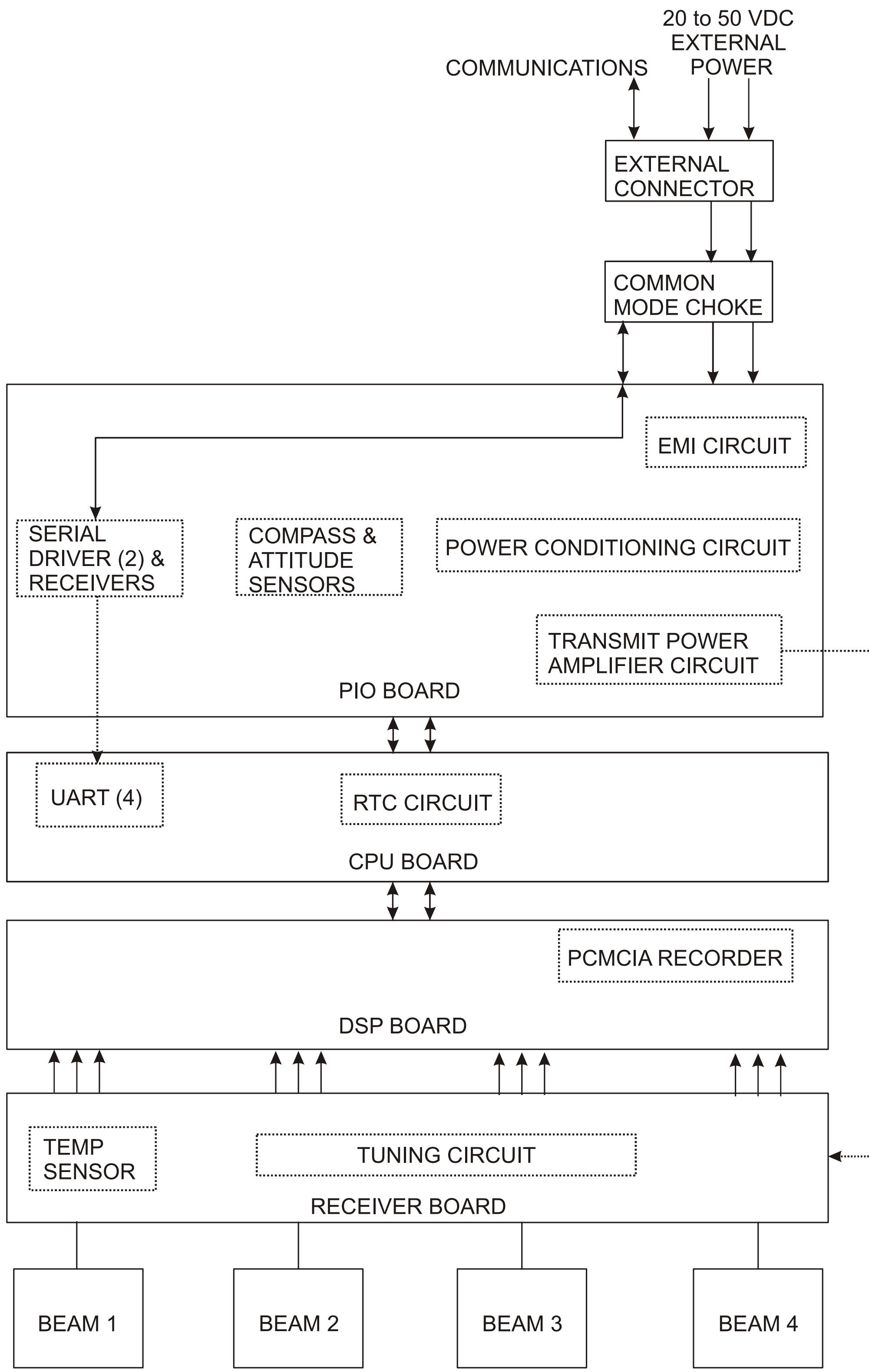


Figure 36. Navigator Block Diagram

8 Introduction to Navigator Commands

This section defines the commands used by the Navigator. These commands (Table 20, page 127) let you set up and control the Navigator without using an external software program such as our *PlanADCP*, *VmDas*, and *WinRiver* programs. However, we recommend you use our software to control the Navigator because entering commands directly from a terminal can be difficult. *Make sure you read and understand "Creating a Command File Using* PlanADCP*," page 122 before deploying your DVL.* Most Navigator settings use factory-set values (Table 21, page 128). If you change these values without thought, you could ruin your deployment. *Be sure you know what effect each command has before using it*. Call TRDI if you do not understand the function of any command.

Using *PlanADCP* to develop the command file will ensure that the Navigator is set up correctly. The commands shown in Table 20, page 127 directly affect the range of the DVL, the standard deviation (accuracy) of the data, and battery usage.

NOTE. This section applies to Navigator firmware 9.20.

When new firmware versions are released, some commands may be modified, added, or removed. Read the README file on the upgrade disk. When an addition or correction to this manual is needed, an Interim Change Notice (ICN) will be posted to our web site. Please check our TRDI's web site often at www.rdinstrument.com.

8.1 Data Communication and Command Format

You can enter commands with an IBM-compatible computer running TRDI's *BBTalk*. The Navigator communicates with the computer through an RS-232 (or RS-422) serial interface. We initially set the Navigator at the factory to communicate at 9600 baud, no parity, and one stop bit.

Immediately after you apply power to the Navigator, it enters the STANDBY mode. Send a BREAK signal using *BBTalk* by pressing the **End** key. When the Navigator receives a BREAK signal, it responds with a wake-up message similar to the one shown below. The Navigator is now ready to accept commands at the ">" prompt from either a terminal or computer program.

```
[Break Wakeup A]
Navigator DVL Version 9.xx
RD Instruments (c) 1996-2005
All rights reserved.
>
```

NOTE. If you use a terminal/program other than *BBTalk*, the BREAK length (up to down transition) must last at least 300 ms.

8.1.1 Command Input Processing

Input commands set Navigator operating parameters, start data collection, run built-in tests (BIT), and asks for output data. All commands are ASCII character(s) and must end with a carriage return (CR). For example,

```
>BP0001<CR> [Your input]
```

If the entered command is valid, the Navigator executes the command. If the command is one that does not provide output data, the Navigator sends a carriage return line feed <CR> <LF> and displays a new ">" prompt. Continuing the example,

```
>BP00001<CR>      [Your original input]
>                 [Navigator response to a valid, no-output command]
```

If you enter a valid command that produces output data, the Navigator executes the command, displays the output data, and then redisplays the ">" prompt. Some examples of commands that produce output data are ? (help menus), CS (start pinging), PS (system configuration data), and PA (run built-in tests).

If the command is not valid, the Navigator responds with an error message similar to the following.

```
>BPA<CR>                                     [Your input]
>BPA  ERR 002:  NUMBER EXPECTED<CR><LF>      [Navigator response]
>
```

After correctly entering all the commands for your application, you would send the CS-command to begin the data collection cycle.

8.1.2 Data Output Processing

After the Navigator completes a data collection cycle, it sends a block of data called a *data ensemble*. A data ensemble consists of the data collected and averaged during the ensemble interval (see TE-command). A data ensemble can contain header, leader, velocity, correlation magnitude, echo intensity, percent good, and status data.

Navigator output data can be in either hexadecimal-ASCII (Hex-ASCII) or binary format (set by CF-command). The Hex-ASCII mode is useful when you use a terminal to communicate with, and view data from the Navigator. The binary mode is useful for high-speed communication with a computer program. You would not use the binary mode to view data on a terminal because the terminal could interpret some binary data as control codes.

> **NOTE.** All of RD Instruments' software supports binary PD0 Output Data Format only.

When data collection begins, the Navigator uses the settings last entered (user settings) or the factory-default settings. The same settings are used for the entire deployment.

The Navigator automatically stores the last set of commands used in RAM. The Navigator will continue to be configured from RAM until it receives a CR-command or until the RAM loses its backup power. If the Navigator receives a CR0 it will load into RAM the command set you last stored in non-volatile memory (semi-permanent user settings) through the CK-command. If the Navigator receives a CR1, it will load into RAM the factory default command set stored in ROM (permanent or factory settings).

8.2 Firmware Updates

The firmware for Navigator DVLs is located on flash memory chips on the CPU board. New firmware must be downloaded. To download new firmware, do the following steps.

> **NOTE.** The CPU board must have EEPROM Parts installed to install version 9.xx or higher firmware. The firmware upgrade program checks if the DVL is capable of upgrading to the new version of firmware.

a. Set up the Navigator as shown in "Setup the Navigator," page 11.

b. Start the program WH*x*.exe (where *x* = the firmware version). Click **Setup**.

c. Click the **View README.TXT** button to view the Readme.txt file for details on what is new in this version of firmware.

d. Click **Next** and follow the on-screen prompts.

e. If you are not able to install the new version of firmware, contact Customer Service for assistance.

f. After successfully upgrading the firmware, use *BBTalk* to test the DVL.

8.3 Feature Upgrades

A standard Navigator DVL includes Bottom Track. The feature upgrade installation program is used to install Shallow Water Bottom Track Mode 7, Water Profiling, and the High-Resolution Water-Profiling modes.

NOTE. The upgrade disk is specific to the unit for which it was ordered. DO NOT attempt to install this feature for any other unit.

NOTE. Many feature upgrades require the latest firmware version to be installed in your DVL. If you need to update the firmware, do this before installing the feature upgrade (see “Firmware Updates,” page 120).

NOTE. Contact your local sales representative if you are interested in upgrading your system.

NOTE. Shallow Water Bottom Track Mode 7 can only be installed on 1200kHz systems.

a. Set up the Navigator as shown in “Setup the Navigator,” page 11.

b. Place the feature upgrade disk in the disk drive (usually the “A” drive).

c. Click the Windows **Start** button, and then select **Run**.

d. In the **Open** box, type A:*xxx*.exe, where *xxx* is the DVL’s CPU serial number. The installation program will start (see Figure 37). The program is encoded with the DVL’s serial number and the requested feature upgrade.

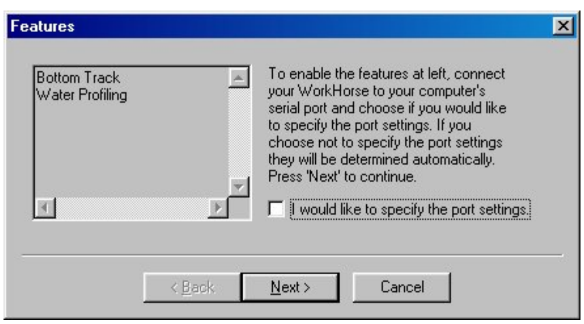


Figure 37. Installing Feature Upgrades

e. To select the port settings, select the **I would like to specify the port setting** box and click **Next**.

f. Select the **Serial Port** and **Baud Rate**.

g. Click **Next** to install the feature upgrade. Click **Finish** to exit the program.

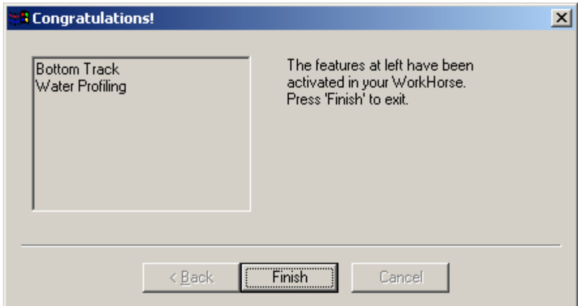


Figure 38. Feature Upgrade Completed

h. Start *BBTalk* and use the OL command (see "OL - Features," page 132) to verify the feature upgrade has been installed.

9 Creating a Command File Using *PlanADCP*

To start *PlanADCP* as a stand-alone module, in Windows®, click **Start**, **Programs**, **RD Instruments**, **PlanADCP** (default location – use your installation settings if different). *PlanADCP* will start and if this is the first time *PlanADCP* is run, it will automatically start the wizard. The next time it is run, it will automatically open the last command file saved. Using the wizard, do the following.

a. Select **Navigator** as the **Type of ADCP**. Click **Next**.

b. Select the frequency of your DVL. The default settings and consequences are based upon the DVL frequency. Click **Next**.

c. Select if the DVL is using batteries. If you select **Yes**, then enter the number of battery packs you are going to use. Click **Next**.

d. Select **Ocean/Near Shore** or **River/Lake** to set the salinity. Water salinity affects the maximum range. Salt water is typically 35 ppt, fresh water is 0 ppt. Click **Next**.

e. Select **Do Not Collect Water Profiles**. Click **Next**.

f. The wizard is now finished. Click **Finish**.

g. Name the command file and click **Save** to save the command file. *PlanADCP* will automatically add the extension *.txt to the file.

   The *PlanADCP* (Basic) Screen opens using the settings you selected with the wizard. The **Basic** screen reflects all of your input during the wizard and is the <u>minimal setup you need to use to collect good data</u>.

h. Review the Storage and Power consequences. Ensure you have enough resources for the deployment.

i. Move the cursor to the **Notes** section. Use the area to include notes about the command file or deployment.

j. If you make any changes to the input parameters, resave the file. On the **File** menu, click **Save** to save the command file.

9.1 Sample Printout of a Command File

Once you have entered all of your choices using *PlanADCP* and saved the file, you can view the command file using the **Expert** screen or on the **File** menu, select **Edit**. Lines beginning with a semicolon (;) are comments. The sample command file shown below is for a 300 kHz Navigator without Water Profiling and using the default settings for all screens.

```
CR1
CF11110
BM5
BP1
BX2500
EA0
EB0
ED0
ES35
EX11111
EZ1111111
TE00:00:00.00
TP00:00.00
CK
CS
;
;Instrument          = Workhorse Navigator
;Frequency           = 307200
;Water Profile       = NO
;Bottom Track        = YES
;High Res. Modes     = NO
;High Rate Pinging   = NO
;Shallow Bottom Mode= NO
;Wave Gauge          = NO
;Lowered ADCP        = NO
;Beam angle          = 30
;Temperature         = 5.00
;Deployment hours    = 24.00
;Battery packs       = 0
;Automatic TP        = YES
;BT range [m]        = 250.00
;Saved Screen        = 1
;
;Consequences generated by PlanADCP version 2.02:
;Ensemble size       = 219 bytes
;Storage required    = 16.91 MB (17733525 bytes)
;Power usage         = 372.01 Wh
;
; WARNINGS AND CAUTIONS:
; The ensemble interval 00:00:01.07 is used for calculations.
```

The commands shown in Table 18, page 124 explain each command set or added by *PlanADCP*. These commands directly affect the range of the DVL, standard deviation (accuracy) of the data, and battery usage. Table 18, page 124 explains the commands used in the sample command file for a 300 kHz Navigator with Bottom Track.

Table 18: Command File Created Using *PlanADCP*

Command	Choices	Description
CR1	Sets factory defaults	This is the first command sent to the ADCP to place it in a "known" state.
CF11110	Flow control	Data recorder turned off.
BM5	Bottom Mode	Bottom Mode 5 selected
BP1	Bottom Track Pings	Ping once per ensemble
BX2500	Maximum Tracking Depth	Sets the maximum tracking depth to 250 meters
EA00000	Heading alignment	Use beam-3 as the heading alignment.
EB00000	Heading bias	Magnetic variation.
ED0000	Transducer depth	Manually set depth of the transducer. If a pressure sensor is installed, the ED-command will be used only if the depth sensor fails.
ES35	Salinity	Salinity of water is set to 35 (saltwater).
EX11111	Coordinate transformations	Sets Earth coordinates, use tilts, allow 3-beam solutions, and allow depth cell (bin) mapping to ON.
EZ1111111	Sensor source	Calculate speed of sound from readings, use pressure sensor (if installed), internal compass, internal tilt sensor, and transducer temperature sensor.
TE00:00:00.00	Time per ensemble	Ping as fast as possible.
TP00:00.00	Time between pings	Ping as fast as possible.
CK	Keep parameters as user defaults	If power is lost and then restored, all commands will be restored as last sent. Sent right before the CS-command.
CS	Start pinging	Last command sent to begin collecting data.

CAUTION. Although these are our recommended minimum commands, **they may not be the only commands you need for your deployment to be successful!**

NOTE. Your deployment may require additional commands and these commands can be sent any time after the CR1 command but must be placed before the CK command. See "Editing the Command File," page 125 for detailed information on editing the command file.

9.2 Editing the Command File

Commands files can be edited in *PlanADCP* two ways: adding commands using Notepad®, or using the **Expert** screen. Editing or adding commands to the command file may not be reflected in the consequences. Therefore, we strongly recommend that you do not change or add any commands unless you are fully familiar with the impact of those changes.

CAUTION. Editing or adding commands to the command file will allow you to set items that if set incorrectly can cause your data to be bad and uncorrectable even in post processing.

Notepad®

To edit the command file in *Notepad*®, do the following.

a. In *PlanADCP*, on the **File** menu, click **Edit**.

b. Select the command file and click the **Edit** button.

c. Make changes to the command file as needed (see Table 19).

d. In *Notepad*, on the **File** menu, click **Save**. Exit *Notepad*® to return to *PlanADCP*.

Expert Screen

PlanADCP's **Expert** screen allows you to view/edit/add commands.

a. To view the **Expert** screen, click the **Advanced** button to move to the **Advanced** screen, and then click the **Expert** button.

b. Click inside the command box to add a command (see Table 19).

Table 19: Recommended Commands to Add or Edit

Command	Choices	Description
BKx	BK0 (default), BK1, BK3	This command selects the frequency of the Water-Mass Layer ping. Recommended to send the BK0 (default) command to disable the Water-Mass Layer (this also disables the BL and BW commands). If you need to enable the Water-Mass Layer pings, see the Navigator Technical Manual command section for detailed information on the BK, BL, and BW commands.
BLmmmm,nnnn,ffff	Min, Near, Far layer boundary	This command sets the Water-Mass Layer boundaries. Recommended to leave at their default settings: BL160,320,480 (300 kHz), BL80,160,240 (600 kHz), BL40,60,100 (1200 kHz).
BWn	BW00001 (default) to BW65535	The BW command sets the ratio of water reference pings to bottom track pings.

Continued Next Page

Table 19: Recommended Commands to Add or Edit (continued)

Command	Choices	Description
BMx	BM4, BM5 (default), BM6, BM7	Sets the Bottom Track mode. Recommended to leave at default setting of Bottom Track Mode 5 (BM5). BM5 switches to BM4 when higher elevation or deeper depth, since BM4 is more efficient in these conditions, and switches back to BM5 when lower elevation for efficiency purposes. In short, BM5 = BM4 (for Long range) and BM5 (for Short Range). BM6 and BM7 require precise command parameters for several commands: BG and BH for BM6, and BX, BV, and &R for BM7. See the “BM - Bottom Track Mode command,” page 144 for details and “FSA-012 - Configuring Bottom Mode 6,” page 328).
CBxxx	CB011 to CB811	Sets the baud rate from 300 to 115200 baud. Recommended to leave at default setting of 9600 baud (CB411).
CTx	CT0 or CT1 (default)	Setting the CT command to CT1 (default) turns the Turnkey mode on. The Navigator DVL will ping when power turned on.
EX10111	Beam, Instrument, Ship, Earth	Change the EX command from EX1**1**111 (set by *PlanADCP*) to EX1**0**111. This sets the Navigator to **Ship coordinates**, use tilts, allow 3-beam solutions, and allow depth cell (bin) mapping to ON.
PDx	PD0 (default), PD3, PD4, PD5, PD6, PD9, PD10, PD11, PD13	Sets the output data format. See the Navigator Technical Manual, Output Data Format section for details.

NOTE. The CR1 command must be the first command sent to the DVL (see Table 18, page 124). The CK command must be sent just before the CS command. Other commands may be sent in any order.

10 Command Summary

Table 20 gives a summary of the Navigator input commands, their format, and a brief description of the parameters they control. Table 21, page 128 lists the factory default command settings.

> **NOTE.** This table shows all commands including optional water profiling feature upgrades and recorder commands (highlighted in yellow). **Some commands may not be available for your DVL.**

> **NOTE.** When newer firmware versions are released, some commands may be modified or added. Read the README file on the upgrade disk or check TRDI's web site for the latest changes.

Table 20: Navigator Input Command Summary

Command	Description
?	Shows command menu (deploy or system)
<BREAK> End	Interrupts or wakes up Navigator and loads last settings used
OL	List features/special firmware upgrades that are installed
AC	Output calibration data
AD	Display factory calibration
AF	Field calibrate compass to remove hard iron error
AR	Return to factory calibration
AX	Examine compass performance
AZ	Zero pressure sensor
BA*nnn*	Evaluation amplitude minimum (1 to 255 counts)
BB*nnnn*	High Bandwidth Maximum Depth (dm)
BC*nnn*	Correlation Magnitude minimum (0 to 255 counts)
BD*nnn*	Delay Before Reacquire (0 to 999 ensembles)
BE*nnnn*	Error velocity maximum (0 to 9999 mm/s)
BF*nnnn*	Depth guess (1 to 65535 dm, 0 = automatic)
BG x,yy,zzz	BM6 Transmit Restriction
BH x,y,zzzz	BM6 Configuration
BI*nnn*	Gain switch depth (0 to 999 meters)
BK*n*	Water-mass Layer Mode (0-Off, 1-On, 2-Lost, 3-No BT)
BL*mmm,nnnn,ffff*	Water mass layer parameters: Min Size (dm), Near (dm), Far (dm)
BM*n*	Bottom track mode (5 = Default, 4 = Default minus Coherent) 6, 7 (upgrade)
BN*x,y*	Speed log hold/drop control (x = hold (1), clear (0), y = 0 to 999 seconds)
BO*k*	Distance measure filter constant (0 to 100 1/100th s)
BP*nnn*	Bottom Track Pings per Ensemble
BR*n*	Resolution (0 = 4%, 1 = 2%, 2 = 1%)
BS	Clear distance traveled
BV aaaaa, bbb, c	Mode 7 Parameters
BWn	Water reference interval
BX*nnnn*	Maximum Tracking Depth (40 to 65535 dm)
BZ*nnn*	Coherent ambiguity velocity (cm/s radial)
CA	Control Periodic Output
CB*nnn*	Serial port control (baud rate/parity/stop bits)
CF*nnnn*	Flow control
CK	Keep parameters as user defaults
CLn	Battery Saver Mode (0 = Do not sleep, 1 = Sleep between pings)
CN*n*	Save NVRAM to recorder (0 = On, 1 = Off)
CR*n*	Retrieve parameters (0 = User, 1 = Factory)
CS or **Tab**	Start pinging
CTn	Turnkey operation (0 = Off, 1 = On)
CX*n*	Enables/disables the low latency trigger (0 = Off, 1 = On)
CY	Clear error status word
CZ	Power down Navigator
EA±*nnnn*	Heading alignment (-179.99 to 180.00 degrees)
EB±*nnnn*	Heading bias (-179.99 to 180.00 degrees)
EC*nnnn*	Speed of Sound (1400 to 1600 m/s)
ED*nnnn*	Transducer Depth (0 to 65535 dm)
EF	Pressure Smoothing Constant (1 to 100, 100 = off)
EH*nnnn*	Heading (000.00 to 359.99 degrees)

Continued Next Page

Table 20: Navigator Input Command Summary (continued)

Command	Description
EP±*nnnn*	Pitch (-60.00 to +60.00 degrees)
EQn	Enable Single Beam Data
ER±*nnnn*	Roll (-60.00 to +60.00 degrees)
ES*nn*	Salinity (0 to 40 parts per thousand)
ET±*nnnn*	Temperature (-5.00 to +40.00 degrees C)
EX*nnnn*	Coordinate Transformation (Xform:Type; Tilts; 3Bm; Map)
EZ*nnnnnn*	Sensor Source (C;D;H;P;R;S;T)
FC	Clear Fault Log
FD	Display Fault Log
PA	Pre-deployment tests
PC1	Beam Continuity Built-in test
PC2	Display Heading, Pitch, Roll, and Orientation Built-in test
PD*n*	Data stream select (0 to 13)
PF	Pre-deployment test summary
PM	Distance measurement facility
PS0	Display System Configuration
PS3	Display Instrument Transformation Matrix
PT*nnn*	Built-In test (0 to 200)
RA	Number of deployments
RB	Recorder built-in test
RE ErAsE	Erase recorder
RF	Recorder free space (Bytes)
RN	Set deployment name
RR	Show recorder file directory
RS	Recorder free space (Megabytes)
RY	Upload recorder files
SAxyz	Synchronize before/after ping/ensemble
SI*nnnn*	Synchronization interval (0 to 65535 s)
SM*n*	RDS3 mode select (0 = Off, 1 = Master, 2 = Slave)
SS*x*	RDS3 sleep mode (0 = No Sleep, 1 = Sleep)
ST*n*	Slave timeout (0 to 10800 seconds)
SW*n*	Synchronization delay (0m to 65535 (1/10 milliseconds))
TBhh:mm:ss.ff	Time per burst
TC*nnnn*	Ensemble per burst (0 to 65535)
TEhh:mm:ss.ff	Time per ensemble (hours:minutes:seconds.100th of seconds)
TFyy/mm/dd, hh:mm:ss	Time of first ping (year/month/day, hours:minutes:seconds)
TGccyy/mm/dd, hh:mm:ss	Time of first ping (Y2k compatible) (century year/month/day, hours:minutes:seconds)
TPmm:ss.ff	Time between pings (minutes:seconds.100th of seconds)
TSyy/mm/dd, hh:mm:ss	Set real-time clock (year/month/day, hours:minutes:seconds)
TTccyy/mm/dd, hh:mm:ss	Set real-time clock (Y2k compatible) (century year /month/day, hours:minutes:seconds)
WA*nnn*	False target threshold maximum (0 to 255 counts)
WB*n*	Mode 1 Bandwidth Control (0 = Wide, 1 = Narrow)
WC*nnn*	Low correlation threshold (0 to 255 counts)
WD*nnn nnn nnn*	Data Out (Vel;Cor;Amp PG;St;P0 P1;P2;P3)
WE*nnnn*	Error correlation threshold (0 to 5000 mm/s)
WF*nnnn*	Blank after transmit (0 to 9999 cm)
WIn	Clip data past bottom (0 = Off, 1 = On)
WJn	Receiver gain select (0 = Low, 1 = High)
WLsss,eee	Water reference layer
WMn	Water Profiling mode (1, 5, 8)
WN*nnn*	Number of depth cells (1 to 128)
WP*nnnn*	Pings per ensemble (0 to 16384)
WQn	Sample ambient sound (0 = Off, 1 = On)
WS*nnnn* [min, max]	Depth cell size (80 to 3200 (75kHz), 40 to 3200 (150kHz), 20 to 800 (300kHz), 10 to 800 (600kHz), 5 to 400 (1200kHz))
WT*nnnn*	Transmit length (0 to 3200 cm)
WV*nnn*	Ambiguity velocity (002 to 480 cm/s radial)
WZ*nnn*	Mode 5 ambiguity velocity (0 to 999 cm/s)

Table 21: Navigator Factory Defaults

Command	300 kHz	600 kHz	1200 kHz
BA	030	030	030
BB	0320	160	60
BC	220	220	220
BD	000	000	000
BE	1000	1000	1000
BF	00000	00000	00000
BG	0,30,0	0,30,0	0,30,0
BH	3,0,0	3,0,0	3,0,0
BI	020	010	005

Continued Next Page

Table 21: Navigator Factory Defaults (continued)

Command	300 kHz	600 kHz	1200 kHz
BK	0	0	0
BL	160,320,480	80,160,240	40,60,100
BM	5	5	5
BN	0,25	0,25	0,25
BO	25	25	25
BP	000	000	000
BR	0	0	0
BV	N/A	20,250,0	10,250,0
BW	00001	00001	00001
BX	02000	1250	450
BZ	004	004	004
CA	0	0	0
CB	411	411	411
CF	11111	11111	11111
CL	1	1	1
CN	1	1	1
CT	1	1	1
CX	0	0	0
EA	+00000	+00000	+00000
EB	+00000	+00000	+00000
EC	1500	1500	1500
ED	00000	00000	00000
EF	100	100	100
EH	00000	00000	00000
EP	+0000	+0000	+0000
EQ	0	0	0
ER	+0000	+0000	+0000
ES	35	35	35
ET	+2500	+2500	+2500
EX	11111	11111	11111
EZ	1111101	1111101	1111101
PD	0	0	0
RN	_RDI_	_RDI_	_RDI_
SA	001	001	001
SI	00000	00000	00000
SM	0	0	0
SS	0	0	0
ST	00000	00000	00000
SW	00075	00075	00075
TB	00:00:00.00	00:00:00.00	00:00:00.00
TC	00000	00000	00000
TE	01:00:00.00	01:00:00.00	01:00:00.00
TP	01:20.00	01:20.00	01:20.00
WA	050	050	050
WB	0	0	0
WC	064	064	064
WD	111 100 000	111 100 000	111 100 000
WE	2000	2000	2000
WF	0176	0088	0044
WI	0	0	0
WJ	1	1	1
WL	001,005	001,005	001,005
WM	1	1	1
WN	030	030	030
WP	00045	00045	00045
WQ	0	0	0
WS	0400 [20,1600]	0200 [10,800]	0100[5,400]
WT	0000	0000	0000
WV	175	175	175
WZ	010	010	010

NOTE. The highlighted commands have frequency dependent defaults.

11 Command Descriptions

Each listing includes the command's purpose, format, default setting (if applicable) range, recommended setting, and description. When appropriate, we include amplifying notes and examples. If a numeric value follows the command, the Navigator uses it to set a processing value (time, range, percentage, processing flags). All measurement values are in metric units (mm, cm, and dm).

? – Help Menus

Purpose Lists the major help groups.

Format *x*? (see description)

Description Entering ? by itself displays all command groups. To display help for one command group, enter *x*?, where *x* is the command group you wish to view. When the Navigator displays the help for a command group, it also shows the format and present setting of those commands. To see the help or setting for one command, enter the command followed by a question mark. For example, to view the WP-command setting enter WP?.

Examples See below.

```
>
[BREAK Wakeup A]
Navigator Broadband ADCP Version 9.20
RD Instruments (c) 1996-2005
All Rights Reserved.
>?
DEPLOY? ------------------ Deployment Commands
SYSTEM? ------------------ System Control, Data Recovery and Testing Commands

>deploy?
Deployment Commands:

BF = 00000 --------------- Depth Guess (0=Auto, 1-65535 = dm)
BK = 00000 --------------- Layer Mode (0-Off, 1-On, 2-Lost, 3-No BT)
BL = 040,060,100 --------- Layer:  Min Size (dm), Near (dm), Far (dm)
BP = 001 ----------------- Pings per Ensemble
BS ----------------------- Clear Distance Traveled
BX = 00450 --------------- Maximum Depth (40-65535 dm)

PA ----------------------- Pre-Deployment Tests

RE ----------------------- Recorder ErAsE
RN ----------------------- Set Deployment Name

TE = 00:00:01.00 --------- Time per Ensemble (hrs:min:sec.sec/100)
TP = 00:00.00 ------------ Time per Ping (min:sec.sec/100)
TS = 05/08/30,09:14:03 --- Time Set (yr/mon/day,hour:min:sec)

ES = 35 ------------------ Salinity (0-40 pp thousand)

CF = 11110 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)
CS ----------------------- Start Deployment
```

```
>system?
System Control, Data Recovery and Testing Commands:

CB = 411 ----------------- Serial Port Control (Baud; Par; Stop)
CK ----------------------- Keep Parameters as USER Defaults
CR # --------------------- Retrieve Parameters (0 = USER, 1 = FACTORY)
CZ  ---------------------- Power Down Instrument

RR ----------------------- Recorder directory
RF ----------------------- Recorder Space used/free (bytes)
RY ----------------------- Upload Recorder Files to Host

PA ----------------------- Pre-Deployment Tests
PC1 ---------------------- Beam Continuity
PC2 ---------------------- Sensor Data
PS0 ---------------------- System Configuration
PS3 ---------------------- Transformation Matrices
>
```

Break

Purpose Interrupts Navigator without erasing present settings.

Format <BREAK>

Recommended Setting. Use as needed.

Description A BREAK signal interrupts Navigator processing. It is leading-edge triggered and must last at least 300 ms. A BREAK initializes the system, sends a wake-up (copyright) message, and places the Navigator in the DATA I/O mode. The BREAK command does not erase any settings or data. Using *BBTalk*, pressing the **End** key sends a BREAK.

Example <BREAK>

```
[BREAK Wakeup A]

Navigator DVL Version 9.xx
RD Instruments (c) 1996-2000
All Rights reserved.
>?
```

When you send a break the text inside the brackets '[…]' of the first line of the Wakeup Messages indicates the DVL communication configuration:

[BREAK Wakeup A] => DVL is set to send/receive RS232 communication through the serial lines of the I/O cable

[BREAK Wakeup B] => DVL is set to send/receive RS432 communication through the serial lines of the I/O cable.

[BREAK Wakeup AB] => RS232/422 switch on the top of the PIO board in the DVL is in between two positions, but neither RS232 nor RS422. It can also mean that the DVL received a trigger pulse while in command mode.

[ALARM Wakeup A] => When you send a break, if the battery has a low voltage reading you will get the following message:

```
[ALARM Wakeup A]
Navigator Broadband ADCP Version 9.20
RD Instruments (c) 1996-2005
All Rights Reserved.
>
```

> **CAUTION.** If this message appears after a break, it is advised not to deploy the DVL since we cannot guarantee the unit will perform to the performance specifications.

Software Breaks

To send the Navigator a soft break from the command prompt, send +++<CR>.

> **NOTE.** In order for the software breaks to work, the CL command must be set to CL0 (see "CL - Battery Saver Mode," page 156).

OL - Features

Purpose Lists special firmware upgrades that are installed.

Format OL

> **Recommended Setting.** Use as needed.

Description Lists special features that are installed. See "Feature Upgrades," page 121 for information on how to install additional capability in your Navigator.

```
>ol                             FEATURES
---------------------------------------------------------------------
Feature                                                     Installed
---------------------------------------------------------------------
Bottom Track                                                    Yes
Water Profile                                                    No
High Resolution Water Modes                                      No
Lowered ADCP                                                     No
Waves Gauge Acquisition                                          No
See your technical manual or contact TRDI for information on how to
install additional capability in your Navigator.
```

11.1 Compass Commands

The main reason for compass calibration is battery replacement. Each new battery carries a different magnetic signature. The compass calibration algorithm corrects for the distortions caused by the battery to give you an accurate measurement.

11.1.1 Available Compass Commands

This section lists the available compass commands.

```
>A?
Available Commands:

AD ----------------------- Display Calibration Data
AF ----------------------- Field Calibrate to remove Hard and/or Soft Iron Error
AR ----------------------- Restore Factory Fluxgate Calibration data:
                              make factory the active calibration data
AX ----------------------- Examine Compass Performance
AZ   0.000000 ------------ Zero pressure reading
A? ----------------------- Display Public Sensor Commands
```

11.1.2 Compass Command Descriptions

AC – Output Active Calibration Data

Purpose Outputs active fluxgate and tilt calibration data.

NOTE. The AC command is not available for Navigator DVLs.

Format AC

Recommended Setting. Use as needed.

Description The AC command is identical to the AD command except that the AC command doesn't prompt the user for Factory or Active Calibration data; it assumes active. The AC Command doesn't prompt the user to "press any key to continue..." when the screen is full.

Example See below

```
>ac

              ACTIVE FLUXGATE CALIBRATION MATRICES in NVRAM
               Calibration date and time: 4/6/2000  11:00:29
                             S inverse
          +                                                   +
     Bx   ¦   2.8071e-01 -2.8343e-01 -3.8045e-02  1.1574e-02 ¦
     By   ¦   8.6383e-04  1.8275e-03 -3.8555e-01  2.9522e-03 ¦
     Bz   ¦  -1.3365e-01 -1.2769e-01  4.9614e-03 -2.2870e-01 ¦
     Err  ¦   3.5561e-01  3.3613e-01 -6.3830e-04 -3.9550e-01 ¦
          +                                                   +
                             Coil Offset
                         +                +
                         ¦   3.4253e+04   ¦
                         ¦   3.5362e+04   ¦
                         ¦   3.5650e+04   ¦
```

```
                   ¦   3.3749e+04   ¦
                   +                +
                       Electrical Null
                        +       +
                        ¦ 34575 ¦
                        +       +
              TILT CALIBRATION MATRICES in NVRAM
          Calibration date and time: 4/6/2000  10:58:42
        Average Temperature During Calibration was   26.6 °C

             Up                               Down

       +                          +     +                           +
Roll   ¦  -3.2219e-07  -1.1456e-05 ¦     ¦   4.2529e-07   1.6306e-05 ¦
Pitch  ¦  -1.1477e-05   8.4276e-08 ¦     ¦  -1.6188e-05   1.9917e-07 ¦
       +                          +     +                           +

       +                          +     +                           +
Offset ¦   3.2400e+04   3.2470e+04 ¦     ¦   3.0128e+04   3.2002e+04 ¦
       +                          +     +                           +

                       +       +
              Null     ¦ 33336 ¦
                       +       +
```

AD – Display Factory or Active Calibration Data

Purpose Displays factory calibration or active calibration data.

Format AD

> **Recommended Setting.** Use as needed.

Description Displays factory calibration or active calibration data.

Example >AD

```
Display factory calibration data or active calibration data [f or a]?a

              ACTIVE FLUXGATE CALIBRATION MATRICES in FLASH
               Calibration date and time: 3/8/1996  09:53:42
                              S inverse
          |                                                   |
     Bx   |   2.9102e-01  2.6325e-01  2.1267e-02  4.0145e-01 |
     By   |   2.7342e-01  2.5335e-01 -4.8691e-02 -3.9508e-01 |
     Bz   |  -1.8192e-01  2.0180e-01  2.3319e-01 -2.7045e-02 |

     Err  |   3.9761e-01 -3.9925e-01  6.4865e-01 -6.0795e-02 |
          |                                                   |
                              Coil Offset
                         |                 |
                         |   3.5076e+04    |
                         |   3.3277e+04    |
                         |   3.2996e+04    |
                         |   3.3953e+04    |
                         |                 |
                              Electrical Null

                               |       |
                               | 33901 |
                               |       |   press any key to continue...

                    TILT CALIBRATION MATRICES in FLASH
                Calibration date and time: 12/28/1995  08:13:29
              Average Temperature During Calibration was   23.4° C

                   Up                                Down
```

```
         |                          |     |                          |

Roll     |  -2.1990e-05  -2.8379e-05 |     |   2.6648e-05   3.4953e-05 |
Pitch    |  -2.9185e-05   2.2630e-05 |     |  -3.5895e-05   2.8521e-05 |
         |                          |     |                          |

         |                          |     |                          |
Offset   |   3.1747e+04   3.0144e+04 |     |   3.0434e+04   3.2971e+04 |
         |                          |     |                          |

                              |       |

                    Null      | 33408 |
                              |       |
```

AF – Field Calibrate Compass

Purpose Calibrates the compass to remove hard and soft iron effects.

Format AF

Recommended Setting. Use as needed. The compass must be calibrated if the batteries have been replaced.

Description The built-in automated compass calibration procedures are similar to the alignment verification, but requires three rotations instead of one. The Navigator uses the first two rotations to compute a new calibration matrix and the third to verify the calibration. It will not accept the new matrix unless the calibration was carried out properly, and it asks you to verify that you want to use the new calibration if it is not as good as the previous calibration. While you are turning the Navigator for the two calibration rotations, the Navigator checks the quality of the previous calibration and displays the results. It compares these results with the results of the third calibration rotation.

There are two compass calibrations to choose from; one only corrects for hard iron while the other corrects for both hard and soft iron characteristics for materials rotating with the DVL. Hard iron effects are related to residual magnetic fields and cause single cycle errors while soft iron effects are related to magnetic permeability that distorts the earth's magnetic field and causes double cycle errors. In general, the hard iron calibration is recommended because the effect of hard iron dominates soft iron. If a large double cycle error exists, then use the combined hard and soft iron calibration.

NOTE. For details on compass alignment, see "Compass Calibration," page 64.

AR – Return to Factory Calibration

Purpose Returns to the factory calibration matrix.

Format AR

Recommended Setting. Use as needed.

Description If the calibration procedure is not successful (AF-command), return your Navigator to the original factory calibration, by using the AR-command. Try using the AR-command if you have trouble calibrating your compass. In some circumstances, a defective compass calibration matrix can prevent proper calibration.

AX – Examine Compass Calibration

Purpose Used to verify the compass calibration.

Format AX

Recommended Setting. Use as needed.

Description Compass calibration verification is an automated built-in test that measures how well the compass is calibrated. The procedure measures compass parameters at every 5º of rotation for a full 360º rotation. When it has collected data for all required directions, the Navigator computes and displays the results. Pay particular attention to the Overall Error.

Example >AX

```
----------------------------------------------------------------------------
                    TRDI Compass Error Estimating Algorithm

   Press any key to start taking data after the instrument is setup.
   Rotate the unit in a plane until all data samples are acquired...
   rotate less than 5°/sec.  Press Q to quit.

 N       NE       E        SE       S        SW       W        NW       N
 ^                ^                 ^                 ^                 ^
 *************************************************************************
Accumulating data ...
Calculating compass performance ...

                          >>> Total error:   1.5° <<<

Press D for details or any other key to continue...

HEADING ERROR ESTIMATE FOR THE CURRENT COMPASS CALIBRATION:

   OVERALL ERROR:
      Peak Double + Single Cycle Error (should be < 5°):  ± 1.55°
```

```
DETAILED ERROR SUMMARY:
   Single Cycle Error:                              ± 1.54°
   Double Cycle Error:                              ± 0.07°
   Largest Double plus Single Cycle Error:          ± 1.61°
   RMS of 3rd Order and Higher + Random Error:      ± 0.31°

   Orientation:    Down
   Average Pitch: -19.29°        Pitch Standard Dev:     0.28°
   Average Roll:   -0.59°        Roll Standard Dev:      0.31°

Successfully evaluated compass performance for the current compass calibra-
tion.
Press any key to continue...
```

AZ – Zero Pressure Sensor

Purpose Zeros the pressure sensor.

Format AZ

Recommended Setting. Use as needed.

Description This command zeros the pressure sensor at the specific location where the DVL will be used.

NOTE. If the pressure sensor is not installed, using the AZ command will generate the following error.

```
Err: No pressure sensor detected
```

11.2 Bottom Track Commands

The Navigator DVLs use these commands for bottom-tracking applications. Bottom track commands tell the DVL to collect speed-over-bottom data and detected range-to-bottom data. If the DVL were facing UP, all bottom-track information would apply to the surface boundary instead of the bottom boundary. The default state of bottom tracking is on (BP001) for Navigator DVLs. Sending a BP0 command turns off the bottom-tracking process.

11.2.1 Available Bottom Track Commands

This section lists the available Bottom Track commands.

```
>B?
BA = 030 ----------------- Evaluation Amplitude Min (1-255)
BB = 0060 ---------------- High Bandwidth Maximum Depth (dm)
BC = 220 ----------------- Correlation Magnitude Min (0-255)
BD = 000 ----------------- Delay Re-Acquire (# Ensembles)
BE = 1000 ---------------- Max Error Velocity (mm/s)
BF = 00000 --------------- Depth Guess (0=Auto, 1-65535 = dm)
BG = 0,30,000 ------------ Restricted Xmit: Enable; MaxXmit[%]; MaxXmit[ms]
BH = 3,0,0000 ------------ BM6 Configuration BW; Code; Velocity(cm/s)
BI = 005 ----------------- Gain Switch Depth (0-999 meters)
BK = 0 ------------------- Layer Mode (0-Off, 1-On, 2-Lost, 3-No BT)
BL = 040,0060,0100 ------- Layer:  Min Size (dm), Near (dm), Far (dm)
BM = 5 ------------------- Mode (4 = Def, 5 = Coherent, 6 = No Amb. Res.)
BN = 0,999 --------------- Speed Log Hold/Drop Control (hold=1,timeout)
BO = 025 ----------------- Distance Measure Filter Constant (1/100ths)
BP = 001 ----------------- Pings per Ensemble
BR = 0 ------------------- Resolution (0 = 4%, 1 = 2%, 2 = 1%)
BS ----------------------- Clear Distance Traveled
BW = 00001 --------------- Water Reference Interval (0-65535 pings)
BX = 00450 --------------- Maximum Depth (10-65535 dm)
BZ = 004 ----------------- Coherent Ambiguity Velocity (cm/s radial)
```

11.2.2 Bottom Track Command Descriptions

BA - Evaluation Amplitude Minimum

Purpose	Sets the minimum value for valid bottom detection.
Format	BA*nnn*
Range	*nnn* = 1 to 255 counts
Default	BA30

Recommended Setting. The default setting for this command is recommended for most applications.

Description BA sets the minimum amplitude of an internal bottom-track filter that determines bottom detection. Reducing BA increases the bottom-track detection range, but also may increase the possibility of false bottom detections.

BB – High Bandwidth Maximum Depth

Purpose	This command lets the user define the range from the bottom/altitude at which the DVL switches between 25% and 50% bandwidth.
Format	BB*nnnn*
Range	*nnnn* = 0 to 9999 dm
Default	BB0320 (300 kHz), BB160 (600 kHz), BB60 (1200 kHz)

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description	This command lets the user define the altitude at which the DVL switches between 25% and 50% bandwidth. When the vertical range to the bottom is less than BB, the unit operates at 50% bandwidth. When the vertical range is greater than BB, the unit operates at 25% bandwidth. A setting of zero disables 50% bandwidth. A setting of 9999 disables 25% bandwidth.

> **NOTE.** If you are operating behind a fairing/hull, you should consider reducing the default value to start transmitting at 25% earlier if the material is greatly absorbent. Testing is strongly advised to determine the adapted altitude switch.

BC - Correlation Magnitude Minimum

Purpose	Sets minimum correlation magnitude for valid velocity data.
Format	BC*nnn*
Range	*nnn* = 0 to 255 counts
Default	BC220

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description	Sets a minimum threshold for good bottom-track data. The DVL flags as bad any bottom-track data with a correlation magnitude less than this value.

> **NOTE.** A count value of 255 is a perfect correlation (i.e. solid target)

BD - Delay before Reacquire

Purpose	Sets a delay period before trying to reacquire the bottom.

Format BD*nnn*

Range *nnn* = 0 to 999 ensembles

Default BD0

Recommended Setting. The default setting for this command is recommended for most applications.

Description BD sets the number of DVL ensembles to wait after losing the bottom before trying to track it again. In effect, BD reduces the number of bottom-track pings and increases the water-track ping rate when the bottom becomes out of range. If the DVL loses track of the bottom, it immediately transmits a series of search pings. If the DVL can not find the bottom after 16 pings, it will then wait BD ensembles before starting the search sequence again.

Examples If BD = 10, the DVL waits 10 DVL ensembles after the automatic search sequence before beginning the search sequence again. If BD = 0 (default), the DVL continually tries to find the bottom.

BE - Error Velocity Maximum

Purpose Sets maximum error velocity for good bottom-track data.

Format BE*nnnn*

Range *nnnn* = 0 to 9999 mm/s

Default BE1000

Recommended Setting. The default setting for this command is recommended for most applications.

CAUTION. The default setting is set purposely high and as a result effectively disabled. We recommend extreme caution and testing before changing this setting. **Data rejected by this command is lost and cannot be regained.**

Description The DVL uses this parameter to determine good bottom-track velocity data. If the error velocity is greater than this value, the DVL marks as bad all four beam velocities (or all four coordinate velocities, if transformed). If three beam solutions are allowed (see "EX – Coordinate Transformation," page 170) and only three beams are good, then the data is accepted since four good beams are needed for error velocity calculation.

BF - Depth Guess

Purpose: Sets a "best-guess" of expected bottom range for internal calculations.

Format: BF*nnnnn*

Range: *nnnnn* = 1 to 65535 dm (0 = automatic)

Default: BF0

Recommended Setting. The default setting for this command is recommended for most applications.

Description: When set to a non-zero value, the DVL transmits a fixed pulse based on a given bottom range. This is useful for applications with fixed range bottoms. The command reduces the amount of time the DVL uses to search for the bottom if lost.

CAUTION. If improperly set, the DVL may not bottom-track at all if the bottom range varies from the input range.

BG – BM6 Transmit Restriction

Purpose: This command, if enabled, limits transmit to a specified pulse length or a percentage of the depth, whichever is shorter.

CAUTION. This command is used for Bottom Track Mode 6 only. Read "FSA-012 - Configuring Bottom Mode 6," page 328 for instructions on how to configure Bottom Mode 6. Improper configuration can result in wild (unreasonable) data.

Format: BG x,yy,zzz

Range: x = Enable/Disable Transmit Restriction (0 = Restriction off; 1 = Restriction On)

yy = Percent of Depth to Transmit (0 – 50%)

zzz = Transmit Limitation in milliseconds (0 = Frequency Dependent Maximum) 1200kHz – 3 ms, 600kHz – 9 ms, 300kHz – 50 ms, 150kHz – 100 ms

Default: BG 0,30,0

Recommended Setting. The default setting for this command is recommended for most applications.

Description: This command limits the length of transmit when using Bottom Mode 6 only. If transmit is not being limited (x=0), the unit will transmit yy% of the depth. If transmit is being limited (x=1), the unit will transmit the shorter of yy% of the depth or zzz milliseconds.

BH – BM6 Configuration

Purpose: This configures the following parameters of Bottom Mode 6: Bandwidth, Code Length, and Expected Velocity.

> **CAUTION.** This command is used for Bottom Track Mode 6 only. Read "FSA-012 - Configuring Bottom Mode 6," page 328 for instructions on how to configure Bottom Mode 6. Improper configuration can result in wild (unreasonable) data.

Format: BH x,y,zzzz

Range: x = Bandwidth (1 = 6.25%; 3 = 12.5%)

y = Code Length (0 = 7, 1 = 15, 2 = 31, 3 = 63)

zzzz = Lane Center [cm/s] (0 – 1800 cm/s)

Default: BH 3,0,0

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description: The command allows only Bottom Mode 6 to be setup for Low Bandwidth Applications.

BI - Gain Switch Altitude

Purpose: Selects the maximum vertical distance from the transducer to the bottom at which the DVL operates at low gain.

Format: BI*nnn*

Range: *nnn* = 0 to 999 meters

Default: BI020 (300 kHz), BI010 (600 kHz), BI005 (1200kHz)

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description: When the vertical range to the bottom is less than BI, the unit operates in low gain. When the vertical range is greater than BI, internal logic determines which gain (low or high) is optimal. In high backscatter areas, it may be necessary to raise this setting in order to detect bottom throughout the range of the system.

BK - Water-Mass Layer Mode

Purpose	Selects the ping frequency of the water-mass layer ping
Format	BK*n*
Range	*n* = 0 to 3
Default	BK0

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description: BK selects how often the DVL performs a water-mass layer ping while bottom tracking. The number of water-mass layer pings per ensemble is dependent on the BP-command (bottom pings per ensemble) and this command setting. Use the BL-command to set the location of the water-mass layer.

Table 22: Water-Mass Reference-Layer Modes

Command	Description
BK0	Disables the water-mass layer ping.
BK1	Sends a water-mass layer ping after every bottom-track ping (exception if BW > 0, see "BW - Water Reference Interval," page 150).
BK2	Sends a water-mass layer ping after every bottom-track ping that is unable to find the bottom.
BK3	Disables the bottom-track ping and enables the water-mass ping.

BL - Water-Mass Layer Parameters

Purpose	Sets bottom-track water-mass layer boundaries and minimum layer size.
Format	BL*mmm*,*nnnn*,*ffff*
Range	*mmm* = Minimum Layer Size (0 - 999 decimeters) [meters x 10] *nnnn* = Near Layer Boundary (0 - 9999 decimeters) [meters x 10] *ffff* = Far Layer Boundary (0 - 9999 decimeters) [meters x 10]
Default	BL160,320,480 (300 kHz), BL80,160,240 (600 kHz), BL40,60,100 (1200kHz)

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description: The BL-command sets a water-mass layer. You can use this layer as a reference point when the bottom is out of range or is incorrect. Water-mass layer output data are available when both BK - Water-Mass Layer Mode and BP - Bottom-Track

Pings Per Ensemble are nonzero values, and the bottom must be at least the Minimum Layer Size + Near Layer Boundary + 20% of the reported depth away from the transducer. The Far Layer Boundary (ffff) must be less than the maximum profiling distance or the DVL sends Error Code 011.

The user-defined water-mass layer is used unless the layer comes within 20% of the water boundary (sea floor for down-looking systems; surface for up-looking systems). As the user-defined water-mass layer comes within 20% of the boundary (Figure 39, B), the layer compresses in size until the minimum water-mass layer size is reached. When the boundary moves closer to the transducer (Figure 39, C), no water mass ping will be sent.

NOTE. The water-mass layer is operational only if BP > zero and BK > zero.

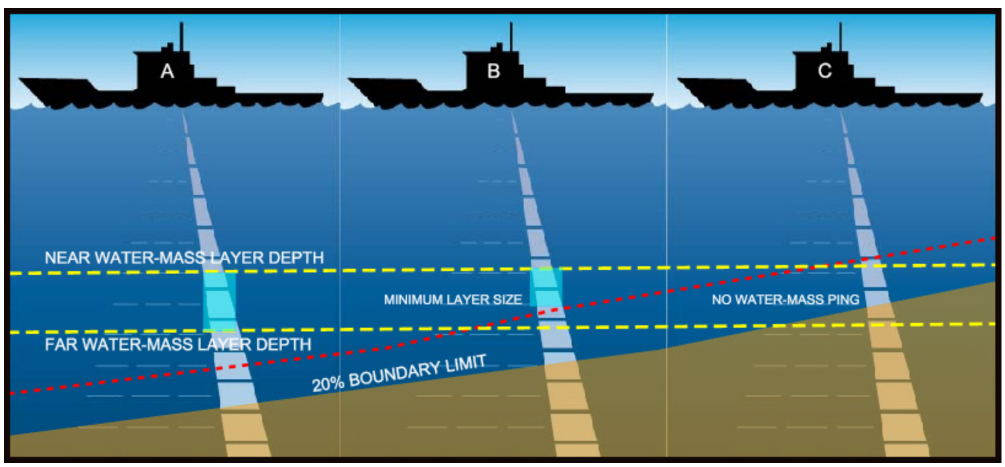


Figure 39. Water-Mass Layer Processing

BM - Bottom Track Mode

Purpose	Sets the Bottom Track mode.
Format	BM*n*
Range	*n* = 4, 5, (see description), 6, 7 (available as a feature upgrade for 1200kHz Navigator DVLs only)
Default	BM5 (300, 600, and 1200 kHz), BM6 (2400 kHz), BM7 (1200 kHz)

Recommended Setting. The default setting for this command is recommended for most applications.

Description	See below

Bottom Track Mode 4

Bottom Track Mode 4 uses the correlation side-peak position to resolve velocity ambiguities. It lengthens the lag at a predetermined depth to improve variance.

Bottom Track Mode 5

Bottom Track Mode 5 is similar to Bottom Track Mode 4, but has a lower variance in shallow water by a factor of up to four. In very shallow water at slow speeds, the variance is lower by a factor of up to 100. Bottom Track Mode 5 also has a slightly slower ping rate than Bottom Track Mode 4.

NOTE. Bottom Mode 5 (default setting) will shift to Bottom Mode 4 if the conditions warrant.

The DVL limits searching for the bottom to the value set by the BX-command (max bottom tracking altitude) + 0.5 transmit length. This allows a faster ping rate when the bottom altitude is close to the BX-command setting.

Table 23: BM4/BM5 Minimum Tracking Depths

Frequency (kHz)	BM4/BM5 Minimum Tracking Depths (m)
150	2.0
300	1.5
600	1.0
1200	0.8

Bottom Track Mode 6

Bottom Mode 6 is a very simple mode. There is no ambiguity resolving, which allows Bottom Mode 6 to operate in Narrower Bandwidths than the standard bottom tracking. Bottom Mode 6 operates in 12.5% and 6.25% Bandwidths. The need for reduced bandwidth could arise to reduce interference or detectability.

Bottom Mode 6, by reducing bandwidth, also reduces sample rate. This results in noisier data. Along with noisy data, comes the complexity of properly configuring the mode. Improper configuration can result in wild (unreasonable) data. If you are interested in using this mode, see "FSA-012 - Configuring Bottom Mode 6," page 328.

Bottom Track Mode 7

NOTE. Bottom Mode 7 is a feature upgrade for 1200kHz Navigator DVLs only (see “Feature Upgrades,” page 121). Contact TRDI for information on how to install this capability in your Navigator.

Bottom Mode 7 has several advantages over BM5 in slow moving, shallow water applications.

Bottom Mode 7 was developed for even shallower applications than Mode 5 yet it retains bottom Mode 5’s very precise velocity measurement (see Table 24). It addresses other shallow water issues such as bottom detection in the presence of high backscatter water, signal level control despite a wide range of bottom backscatter for various applications, and transmit/receive interference when beam depths are substantially different.

Bottom Mode 7 pings at a slower rate than Bottom Mode 5 (1/3 the rate of BM5) and the precision of its velocity measurement degrades at velocities higher than 0.2m/s. If you are interested in using this mode, please contact Field Service for an upgrade of your DVL to high ping rate Bottom Mode7. Also see “FSA-015 - Shallow Water Bottom Tracking Bottom Mode 7,” page 333.

Table 24: BM7 Minimum Tracking Depths

Freq	Min Tracking Depths
1200kHz	0.3m

BN – Speed Log Hold/Drop Control

Purpose: Controls the behavior of the distance measure calculation when Bottom Track is lost.

Format: BNx,y

Range: x = 0 to 1

y = 0 to 999 seconds

Default: BN0,25

Recommended Setting. The default setting for this command is recommended for most applications.

Description: The BN command governs the behavior of the earth referenced distance measurement calculation in the PD5 and PD6 data format when the DVL can’t get a lock on the bottom. The *y* parameter represents a timeout period during which zero is used for the current velocity measurement in the equation shown in the BO command. After the expiration of the *y* timeout, the behavior is governed by the *x* parameter. If *x* is zero, then the accumulated distance is set to zero. If *x* is one, then the accumulated distance is maintained at its current value until the DVL achieves bottom lock.

BO - Distance Measure Filter Constant

Purpose: Sets the value of the filter constant used by the distance measurement calculation in PD5 and PD6.

Format: BO*k*

Range: *k* = 0 to 100

Default: BO25

Recommended Setting. The default setting for this command is recommended for most applications.

Description: When calculating the earth referenced distance data for output in the PD5 and PD6 data format, the DVL applies a simple exponential filter to the velocity measurements before calculating the distance. The velocity used to calculate the distance is given by the following equation: $v = (k \bullet v_{new} + (k - 100) \bullet v_{old}) / 100$

Where v_{new} is the current velocity measurement, v_{old} is the value of v calculated for the previous distance calculation, and k is the value of the BO command. Setting k to 100 effectively disables the exponential filter.

BP – Bottom-Track Pings Per Ensemble

Purpose Sets the number of bottom-track pings to average together in each data ensemble.

Format BP*nnn*

Range *nnn* = 0 to 999 pings

Default BP001

Recommended Setting. The default setting for this command is recommended for most applications.

Description The BP command sets the number of bottom-track pings to average together in each ensemble before sending/recording bottom-track data.

NOTES.

The DVL interleaves bottom-track pings with water-track pings (see “TP – Time Between Pings,” page 199) if water profiling is enabled. If BP = zero, the DVL does not collect bottom-track data. The DVL automatically extends the ensemble interval (TE) if BP x TP > TE.

BR - Resolution

Purpose	Sets the vertical depth resolution.
Format	BRn
Range	n = 0 to 2 (see description)
Default	BR0

Recommended Setting. The default setting for this command is recommended for most applications.

Description BR sets the vertical depth resolution as a percentage of the overall range detected. The lower the resolution, the finer the depth reading. With BR0 set, if you had a depth of 100 meters, then the depth would read 100 meters until you passed 104 meters. If you had BR2 set, then it would change when you reached 101 meters. Setting a higher resolution (e.g. 1%) results in longer ping times.

BR0 = 4% BR1 = 2% BR2 = 1%

Resolution Setting Limitations:

1) Minimum RSSI Bin Size – The RSSI sampling interval cannot be smaller than the minimum RSSI bin size (for example, 5 cm for a 1200 kHz system). This means that you get the resolution that you command in % or 5 cm (for the above example) - whichever is larger. The minimum RSSI bin sizes vary with system frequency according to the following table:

Frequency	Min RSSI Bin Size
150	37 cm
300	18 cm
600	9 cm
1200	5 cm

2) BM5 Low Altitude Minimum RSSI Bin Size -- This limitation affects only Bottom Mode 5 operation below the following altitudes:
300 kHz -- 10 meters -- the resolution becomes 16 cm
600 kHz -- 5 meters -- the resolution becomes 8 cm
1200 kHz -- 2.5 meters -- the resolution becomes 7.8 cm

BS - Clear Distance Traveled

Purpose	Clears internal distance traveled accumulators.
Format	BS

Recommended Setting. Use as needed.

Description	Distance traveled is calculated and output in DVL output formats (PD5 and PD6). The accumulator is zeroed on <BREAK> or by using this command in the manual ensemble cycling mode.

BV – Mode 7 Parameters

Purpose	Controls the behavior of Bottom Track Mode 7.
Format	BV *aaaaa*, *bbb*, *c*
Range	*aaaaa* = 0 to 65535 *bbb* = 0 to 255 *c* = 0 or 1 (0 = Off, 1 = On)
Default:	BV20,250,0 (600kHz), BV10, 250, 0 (1200kHz),

Recommended Setting. The default setting for this command is recommended for most applications.

Description: The first parameter sets the depth at which the bottom will be searched. It avoids locking onto ringing (if any) or very high backscatter water near the transducer.

The second parameter controls the correlation threshold for ambiguity resolving. A lower, fixed correlation threshold is used to determine if a lag's velocity estimate is satisfactory.

The last parameter controls whether short lag velocity estimates are output in the event the longer lag ambiguity cannot be resolved because one or more of the short lag velocity estimates have too low a correlation. If this parameter is a one, then the average of the four short lag estimates that are above a lower, fixed correlation threshold will be used. If this parameter is a zero, then no velocity will be output for this case.

NOTE. A count value of 255 is perfect correlation.

BW - Water Reference Interval

Purpose	This parameter controls the number of bottom track pings between water reference pings per ensemble.
Format	BWn
Range	n = 0 to 65535
Default	BW00001

Recommended Setting. The default setting for this command is recommended for most applications.

Description	The BW command sets the ratio of water reference pings to bottom track pings. Using this command allows you to control how often the water reference ping is done, and therefore the total number of water reference pings per ensemble.
Example	If you wanted to do two water reference pings in an ensemble and BW = 5 (BW5), BP = 10 (BP10), and BK = 1 (BK1), then the DVL will perform five bottom pings, one water reference ping, five bottom pings, then one water reference ping.

NOTE. The BK-command must be set to one (BK1) for this command to work.

BX – Maximum Tracking Depth

Purpose	Sets the maximum tracking depth in bottom-track mode.
Format	BX*nnnn*
Range	*nnnn* = 10 to 65535 decimeters (meters x 10)
Default	BX2000 (300 kHz), BX1250 (600 kHz), BX0450 (1200 kHz),

Recommended Setting. Set BX to a depth slightly greater than the expected maximum depth.

Description	The BX-command sets the maximum tracking depth used by the DVL during bottom tracking. This prevents the DVL from searching too long and too deep for the bottom, allowing a faster ping rate when the DVL loses track of the bottom. If the bottom-track water reference layer is in use (BK > 0), BX must be greater than the Far Layer Boundary (BLmmm,*nnnn*,ffff), or the DVL sends Error Code 012.
Example	If you know the maximum depth in the deployment area is 20 meters (200 decimeters), set BX to a value slightly larger than 200 dm, say 210 dm, instead of the default 1250 dm. Now if

the DVL loses track of the bottom, it will stop searching for the bottom at 210-dm (21 m) rather than spend time searching down to 125-dm (125 m), which is the maximum bottom-tracking range.

BZ - Coherent Ambiguity Velocity

Purpose	Sets the Bottom-Track Mode 5 ambiguity velocity.
Format	BZ*nnn*
Range	*nnn* = 0 to 999 cm/s radial
Default	BZ004

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description	The BZ-command selects the ambiguity velocity used by the bottom-track ping in shallow water when bottom-track Mode 5 is in use.

11.3 Control System Commands

The Navigator DVL uses the following commands to control certain system parameters.

11.3.1 Available Control System Commands

This section lists the available Control System commands.

```
>C?
CA = 000 ----------------- Periodic Output 1/10 sec. (0-Off, [10-600])
CB = 411 ----------------- Serial Port Control (Baud [4=9600]; Par; Stop)
CF = 11110 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)
CK ----------------------- Keep Parameters as USER Defaults
CL = 1 ------------------- Sleep Between Pings (0 = No, 1 = Yes)
CN = 1 ------------------- Save NVRAM to recorder (0 = ON, 1 = OFF)
CR # --------------------- Retrieve Parameters (0 = USER, 1 = FACTORY)
CS ----------------------- Go (Start Pinging)
CT = 1 ------------------- Turnkey (0 = OFF, 1 = ON)
CX = 0 ------------------- Trigger Enable (0 = OFF, 1 = ON)
CY = 00044032 ------------ Clear Error Status Word
CZ ----------------------- Power Down Instrument
```

11.3.2 Control System Command Descriptions

CA - Control Periodic Output

Purpose	Sets the periodic Output Interval in tenths of seconds.
Format	CAnnn
Range	nnn = 0, 10 to 600 tenths of seconds
Default	CA0

Recommended Setting. The default setting for this command is recommended for most applications.

Description: This command sets the periodic output interval in tenths of seconds. Leaving CA at its default of zero disables periodic output. The minimum interval is 1 second and the maximum is 1 minute. This command depends on the triggering being enabled (See "CX – Low Latency Trigger Enable," page 158).

The CA command doesn't set an output; it sets an output rate. It allows the user to set a periodic rate of data output. It is only useful when the CX command is set to CX1. This gives the user the ability to synchronize pings to an external source, while outputting data at a set rate.

CAUTION. Setting the CA command to a non-zero number with the CX command set to 0 will result in non-function of the DVL.

CB - Serial Port Control

Purpose	Sets the RS-232/422 serial port communications parameters (Baud Rate/Parity/Stop Bits).
Format	CB*nnn*
Range	*nnn* = baud rate, parity, stop bits (see description)
Default	CB411

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description The Navigator and your external device (dumb terminal, computer software) MUST use the same communication parameters to *talk* to each other. After you enter valid CB parameters, the Navigator responds with a “>” prompt. You may now change the external device’s communication parameters to match the Navigator parameters before sending another command.

Table 25: Serial Port Control

Baud Rate	Parity	Stop Bits
0 = 300		
1 = 1200	1 = None (Default)	1 = 1 Bit (Default)
2 = 2400	2 = Even	2 = 2 Bits
3 = 4800	3 = Odd	
4 = 9600 (Default)	4 = Low (Space, logical 0)	
5 = 19200	5 = High (Mark, logical 1)	
6 = 38400		
7 = 57600		
8 = 115200		

Setting The Baud Rate In The Navigator. The Navigator can be set to communicate at baud rates from 300 to 115200. The factory default baud rate is always 9600 baud. The baud rate is controlled via the CB-command. The following procedure explains how to set the baud rate and save it in the Navigator. This procedure assumes that you will be using the program *BBTalk* that is supplied by Teledyne RD Instruments.

a. Connect the Navigator to the computer and apply power (see “Setup the Navigator,” page 11).

b. Start the *BBTalk* program and establish communications with the DVL. Wakeup the Navigator by sending a break signal with the **End** key.

c. Send the command CR1 to place the Navigator in the factory default setup.

d. Send the CB-command that selects the baud rate you wish. The following are the typical CB-command settings for different baud rates with no parity and 1 stop bit:

Table 26: Baud Rate

BAUD RATE	CB-command
300	CB011
1200	CB111
2400	CB211
4800	CB311
9600	CB411 (Default)
19200	CB511
38400	CB611
57600	CB711
115200	CB811

e. In *BBTalk*, press **F5** and change the settings to match your CB command settings. Press **OK** to exit the communication setup screen.

f. Send the command CK to save the new baud rate setting.

g. Click **File**, **Close** to exit the terminal window.

The Navigator is now set for the new baud rate. The baud rate will stay at this setting until you change it back with the CB-command.

> **NOTE.** If you send a BREAK before changing the external device's communication parameters, the Navigator returns to the communication parameters stored in non-volatile memory (user settings).

CF - Flow Control

Purpose Sets various Navigator data flow-control parameters.

Format CF*nnnnn*

Range Firmware switches (see description)

Default CF11110

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description The CF-command defines whether the Navigator: generates data ensembles automatically or manually; generates pings immediately or manually; sends serial output data in binary or

Hex-ASCII format; sends or does not send output data to the serial interface; sends or does not send data to the recorder (if installed).

NOTE. The *VmDas* program sets the Navigator to a manual ensemble mode (CF01110) so that it controls when the ensemble occurs.

Table 27: Flow Control

Command	Description
CF1xxxx	Automatic Ensemble Cycling – Automatically starts the next data collection cycle after the current cycle is completed. Only a <BREAK> can stop this cycling.
CF0xxxx	Manual Ensemble Cycling – Enters the STANDBY mode after transmission of the data ensemble, displays the “>” prompt and waits for a new command.
CFx1xxx	Automatic Ping Cycling – Pings immediately when ready.
CFx0xxx	Manual Ping Cycling – Sends a □<□ character to signal ready to ping, and then waits to receive an <Enter> before pinging. The <Enter> sent to the Navigator is not echoed. This feature lets you manually control ping timing within the ensemble.
CFxx2xx	Hex-ASCII Data Output, Carriage Return-Linefeed delimited -- Sends the ensemble in readable hexadecimal-ASCII format with a Carriage Return-Linefeed at the end of each ensemble, if serial output is enabled (see below).
CFxx1xx	Binary Data Output – Sends the ensemble in binary format, if serial output is enabled (see below).
CFxx0xx	Hex-ASCII Data Output – Sends the ensemble in readable hexadecimal-ASCII format, if serial output is enabled (see below).
CFxxx1x	Enable Serial Output – Sends the data ensemble out the RS-232/422 serial interface.
CFxxx0x	Disable Serial Output – No ensemble data are sent out the RS-232/422 interface.
CFxxxx1	Enable Data Recorder – Records data ensembles on the recorder (if installed).
CFxxxx0	Disable Data Recorder – No data ensembles are recorded on the recorder.
Example	CF01010 selects manual ensemble cycling, automatic ping cycling, Hex-ASCII data output, enables serial output, and disables data recording.

CK - Keep Parameters

Purpose Stores present parameters to non-volatile memory.

Format CK

Recommended Setting. The CK command must be sent just before the CS command (see “Creating a Command File Using PlanADCP,” page 122).

Description CK saves the present user command parameters to non-volatile memory on the CPU board. The DVL maintains data stored in the non-volatile memory (user settings) even if power is lost. It does not need a battery. You can recall parameters stored in non-volatile memory with the CR0-command.

CL - Battery Saver Mode

Purpose: Determines whether the DVL will attempt to conserve power by sleeping between pings.

Format: CLn

Range: n = 0 to 1 (Sleep Between Pings (0 = No, 1 = Yes)

Default: CL1

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description: Setting the CL command to CL0 means the DVL will not make any attempt to conserve power. CL1 means the DVL will attempt to conserve power by going to sleep at every opportunity.

> **NOTE.** In order for software breaks to work, the CL-command must be set to CL0.

CN - Save NVRAM to Recorder

Purpose: Saves the contents of NVRAM to the recorder at the end of a deployment.

Format: CN*n*

Range: n = 0 (On), 1 (Off)

Default: CN1

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description: The CN command allows the contents of the NVRAM (approx. 8k bytes) to be written to the recorder as part of the deployment record. This can be useful for troubleshooting purposes.

CR – Retrieve Parameters

Purpose: Resets the Navigator command set to factory settings.

Format: CR*n*

Range: *n* = 0 (User), 1 (Factory)

> **Recommended Setting.** The CR1 command must be the first command sent to the DVL (see “Creating a Command File Using PlanADCP,” page 122).

Description The Navigator automatically stores the last set of commands used in RAM. The Navigator will continue to be configured from RAM unless it receives a CR-command or until the RAM loses its power.

Table 28: Retrieve Parameters

Format	Description
CR0	Loads into RAM the command set last stored in non-volatile memory (user settings) using the CK-Command.
CR1	Loads into RAM the factory default command set stored in ROM (factory settings).

NOTE. CR keeps the present baud rate and does not change it to the value stored in non-volatile memory or ROM. This ensures the Navigator maintains communications with the terminal/computer.

CS – Start Pinging (Go)

Purpose Starts the data collection cycle (same as the **Tab** key).

Format CS

Recommended Setting. Use as needed. Use *WinSC/VmDas/WinRiver* to create the command file. The CS command will be added to the end of the command file or sent by the software.

Description Use CS (or the **Tab** key) to tell the Navigator to start pinging its transducers and collecting data as programmed by the other commands. If the TF-command is set (time of first ping), the Navigator waits until it reaches the TF time before beginning the data collection cycle.

NOTES.

1. After a CS-command is sent to the Navigator, no changes to the commands can occur until a <BREAK> is sent.

2. If you try to record data (CFxxxx1), and the recorder is full, the Navigator will *not* start pinging and will return a *RECORDER NOT READY* message.

CT - Turnkey Operation

Purpose Allows the DVL to initialize to predefined parameters and start pinging immediately after power is applied.

Format CT*n*

Range *n* = 0 to 1 (0 = Off, 1 = Turnkey)

Default CT1

Description Setting the CT command to CT1 lets the DVL automatically initialize to a predefined command set during any power up. To place the DVL in turnkey mode, you must first set all other commands to the desired configuration. You must then send the CT1 and CK commands to save this configuration. When power is cycled, the DVL will start up with the desired configuration and begin the data collection process. You can interrupt (not remove) this mode by sending a <BREAK>. This will place the DVL in the command mode, ready to accept inputs. Cycling the power, however, will again start the data collection process.

To turn off the turnkey mode, first send a <BREAK> to the DVL. Now send the CT0 and CK commands to save this configuration. When power is cycled, the DVL will NOT begin the data collection process.

CX – Low Latency Trigger Enable

Purpose	Enables or disables the low latency trigger.
Format	CX*n*
Range	*n* = 0 (off), 1 (on)
Default	CX0

Recommended Setting. The default setting for this command is recommended for most applications. For more information on using the CX command, see "FSA-018 - Triggering a DVL with a TTL Signal," page 337.

Description Turning on the Low Latency Trigger functionality allows the Navigator to ping within ~300µs of the rising edge of the trigger. The trigger needs to be on a differential signal pair that starts with a rising edge on one signal line and a falling edge on the other signal line.

CAUTION. The CX command inhibits the ability of the Navigator to sleep and conserve power. Use CX1 only when power consumption is not an issue.

NOTE. If CX1 is used, the CL command must be set to CL0 (see "CL - Battery Saver Mode," page 156).

CY - Clear Error Status Word

Purpose Clears the Error Status Word (ESW) stored in EEPROM on the CPU. The ESW is updated whenever an error occurs.

Format Use the CY command to display the ESW value or to clear the ESW.

Recommended Setting. Use as needed.

Description CY displays the active ESW value, which is a 32-bit value displayed in Hex ASCII.

Table 29: Error Status Word

ESW	Description
0x00000001	Bus Error Exception occurred.
0x00000002	Address Error Exception occurred.
0x00000004	Illegal Inst Exception occurred.
0x00000008	Zero Divide Exception occurred.
0x00000010	Emulator Exception occurred.
0x00000020	Unassigned Exception occurred.
0x00000040	Watchdog restart occurred.
0x00000080	Screen Save power down occurred.
0x00000100	Currently pinging.
0x00000200	Unused
0x00000400	Unused
0x00000800	Unused
0x00001000	Unused
0x00002000	Unused
0x00004000	Cold wakeup occurred.
0x00008000	Unknown wakeup occurred.
0x00010000	Clock read failure occurred.
0x00020000	Unexpected Alarm.
0x00040000	Clock jump forward.
0x00080000	Clock jump backward.
0x00100000	Unused
0x00200000	Unused
0x00400000	Unused
0x00800000	Unused
0x01000000	Unused
0x02000000	Unused
0x04000000	Unused
0x08000000	Power Fail (Unrecorded)
0x10000000	Spurious level 4 interrupt (DSP).
0x20000000	Spurious level 5 interrupt (UART).
0x40000000	Spurious level 6 interrupt (CLOCK).
0x80000000	Level 7 interrupt occurred.

Error Status Word (ESW) codes can only be cleared through the CY-command. The values are logically OR'ed. For example, if an illegal instruction (xxx4) and a divide by zero error (xxx8) occurred since the last time the ESW was cleared, a value of "xxxC" would appear as the ESW.

NOTE. ESW code 0x0000100 can only be seen if the CY-command is issued between CS-commands in the manual ping mode. This flag is used to determine if on wakeup, whether the DVL was pinging or not previous to the present power up. A CS-command sets this bit; a <BREAK> resets the bit. This results in the following consequences:

a) A deployment must be ended with a <BREAK>. If the DVL is pinging, and power is lost, when power is restored, the DVL will continue to ping.

b) If the DVL is in the command mode when power is lost, when power is restored, it will wakeup in the command mode. If a timeout occurs, the DVL will power down automatically.

NOTE. The ESW is written to the ensemble (see Figure 45, page 225). The ESW is cleared (set to zero) between each ensemble.

CZ – Power Down Navigator

Purpose Tells the Navigator to power down.

Format CZ

Recommended Setting. Use as needed.

Description Sending the CZ-command powers down the Navigator. Navigator processing is interrupted and the Navigator goes in the STANDBY mode (RAM is maintained).

NOTES.

1. When powered down using the CZ-command, the Navigator still draws up to 30µa, but wakes up periodically (every 8 to 12 hours) for a few seconds to maintain RAM.

2. This command should be used whenever batteries have been installed and you do not send commands to start a deployment. If you do not use the CZ-command, the Navigator will draw up to 50 milli-amps of current. *A new battery will be discharged in a few days*.

3. Performance and testing commands (i.e. AF, PA, PT, RB, and RY) override the battery saver functions. For example, using the RY-command to recover data from the DVL while on battery power will disable the automatic power saver mode. If a CZ-command is not used after all data has been recovered, the DVL will remain in the command mode. TRDI recommends disconnecting the batteries and using the AC power adapter while testing or recovering data.

11.4 Sound Velocity Smart Sensor Commands

The Navigator uses these commands for Sound Velocity Smart Sensor (SVSS) applications.

The Navigator may accept the RS485 input of an Applied Microsystems Limited Sound Velocity Smart Sensor (SVSS) to correct for speed of sound. This may be achieved by using the DVL in RS232 and accepting the data in RS485 from the SVSS. Customers are advised to contact TRDI for further information on this interface as some modification to the DVL may be required.

CAUTION. The SVSS sensor must be tested with the DVL before deployment.

11.4.1 Available Sound Velocity Smart Sensor Commands

This section lists the available Sound Velocity Smart Sensor commands.

```
>d?
Available Commands:

DW  0 -------------------- Current ID on RS-485 Bus
DB 411 ------------------- RS-485 Port Control (Baud; N/U; N/U)
DX ----------------------- Set SVSS to RAW Mode
DY ----------------------- Set SVSS to REAL Mode
DZ ----------------------- Get Single SCAN from SVSS
DS    0 0 ---------------- Load SpeedOfSound with SVSS Sample (BITResult)
D? ----------------------- Display SVSS Commands
```

11.4.2 Sound Velocity Smart Sensor Command Descriptions

DB – RS-485 Port Control

Purpose	Change the communication parameters of the RS-485 bus.
Format	DBxyz
Range	x = 0 to 7 Baud Rate (see "CB - Serial Port Control," page 153). y =l to 5 Unused z =l to 2 Unused
Default	DB411

Recommended Setting. Use as needed.

Description	This command changes the communication parameters of the RS-485 bus. Currently only the Baud Rate is changed, but all parameters are still required.

DS – Load SpeedOfSound with SVSS Sample (BIT Result)

Purpose Load the SpeedOfSound variable with a single real scan from the SVSS.

Format DS

Recommended Setting. Use as needed.

Description This command loads the SpeedOfSound variable with a measured value from the SVSS, in a manner similar to the manner the variable is loaded during deployment. The EZ command must be issued prior to this command or the function will be bypassed. Set the EZ command to EZ3xxxxxx. The three enables communication with the SVSS. Upon successful completion of the function call, the SpeedOfSound variable will contain the new value. Any errors in the function will result in the BIT Result (Table 46, page 226) = xxxxxlxx xxxxxxxx which is displayed after the value.

DW – Current ID on RS-485 Bus

Purpose Change the device ID sent out before attempting to communicate.

Format DWx

Range x = 0 to 31

Default DW0

Recommended Setting. Use as needed.

Description This commands sets the RS-485 Bus ID and sends the ID out onto the bus with the parity forced high. This wakes up the slave device for communications.

DX – Set SVSS to RAW Mode

Purpose Set the SVSS to Raw mode.

Format DX

Recommended Setting. Use as needed.

Description This command sends “RA” out on the RS-485 bus. If the SVSS is listening, it will change its data output mode to RAW. RAW data is columnar uncalibrated counts.

DY – Set SVSS to REAL Mode

Purpose Set the SVSS to Real mode.

Format DY

Recommended Setting. Use as needed.

Description This command sends "RE" out on the RS-485 bus. If the SVSS is listening, it will change its data output mode to REAL. REAL data is in units of m/s and the form XXXX.XX.

DZ - Get Single SCAN from SVSS

Purpose This command gets a single scan of data from the SVSS.

Format DZ

Recommended Setting. Use as needed.

Description This command sends "s" out on the RS-485 bus. If the SVSS is listening, it will respond (-23ms later) with one scan of data. The data format will be determined by the last format command ("DX" or "DY") sent to the SVSS. The data will be echoed back by the ADCP.

11.5 Environmental Commands

The Navigator uses the following commands to control the environmental and positional information that affects internal data processing.

11.5.1 Available Environmental Commands

This section lists the available Environmental commands.

```
>E?
EA = +00000 -------------- Heading Alignment (1/100 deg)
EB = +00000 -------------- Heading Bias (1/100 deg)
EC = 1500 ---------------- Speed Of Sound (m/s)
ED = 00000 --------------- Transducer Depth (0 - 65535 dm)
EF = 100 ----------------- Pressure Smoothing Constant (1-100,100=off)
EH = 00000 --------------- Heading (1/100 deg)
EP = +0000 --------------- Tilt 1 Sensor (1/100 deg)
EQ = 0 ------------------- Single Beam Use (0-Off, 1-On)
ER = +0000 --------------- Tilt 2 Sensor (1/100 deg)
ES = 35 ------------------ Salinity (0-40 pp thousand)
ET = +2500 --------------- Temperature (1/100 deg Celsius)
EX = 11111 --------------- Coord Transform (Xform:Type; Tilts; 3Bm; Map)
EZ = 1111101 ------------- Sensor Source (C;D;H;P;R;S;T)
```

11.5.2 Environnemental Command Descriptions

EA - Heading Alignment

Purpose	Corrects for physical misalignment between Beam 3 and the heading reference.
Format	EA±*nnnnn*
Range	±*nnnnn* = -17999 to 18000 (-179.99 to 180.00 degrees)
Default	EA00000

> **Recommended Setting.** For systems that are stationary, EA is typically set to zero (default), since Beam 3 is used as the heading reference.

Description	EA is a heading alignment angle (referenced to Beam 3) used as a new zero reference for heading output and for transformation to earth coordinates. Use the EB-command to correct for heading bias (e.g., magnetic declination).
Example	The DVL is mounted in place on a moving ship. Beam 3 has been rotated 45 clockwise (+45) from the ship's centerline. Use the EA command to tell the DVL where beam 3 is in relation to the ship's centerline. To convert +45 to an EA-command value, multiply the desired alignment angle in degrees by 100:

```
EA = +45.00 × 100 = +4500 = EA+04500
```

EB - Heading Bias

Purpose	Corrects for electrical/magnetic bias between the DVL heading value and the heading reference.
Format	EB±*nnnnn*
Range	±*nnnnn* = -17999 to 18000 (-179.99 to 180.00 degrees)
Default	EB00000

> **Recommended Setting.** Use EB to counteract the effects of magnetic declination at the deployment site. Set using *WinSC*, *VmDas*, or *WinRiver*.

Description	EB is the heading angle that counteracts the electrical bias or magnetic declination between the DVL and the heading source. Use the EA-command to correct for physical heading misalignment between the DVL and a vessel's centerline.
Examples	A bottom-mounted DVL is receiving heading from its internal compass. A navigation map for the deployment area shows a declination of 10°10′W 1995 (9′E/year). This means the magnetic offset in the year 2001 at this location is (- (10+10/60) + (9/60*6)) = -9.26666 degrees. Set the EB command value to EB-926.

EC - Speed of Sound

Purpose	Sets the speed of sound value used for DVL data processing.
Format	EC*nnnn*
Range	*nnnn* = 1400 to 1600 meters per second
Default	EC1500

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description	EC sets the sound speed value used by the DVL to scale velocity data, depth cell size, and range to the bottom. The DVL assumes the speed of sound reading is taken at the transducer head. See the primer for information on speed of sound calculations.

> **NOTE.** If the EZ Speed of Sound field = 1, the DVL overrides the manually-set EC value and calculates speed of sound using the values determined by transducer depth (ED), salinity (ES), and transducer temperature (ET). EZ also selects the source for ED, ES, and ET.

ED - Depth of Transducer

Purpose	Sets the DVL transducer depth.
Format	ED*nnnnn*
Range	*nnnnn* = 0 to 65535 decimeters (meters x 10)
Default	ED00000

Recommended Setting. Use the EZ-command (set by *WinSC*).

Description — ED sets the DVL transducer depth. This measurement is taken from sea level to the transducer faces. The DVL uses ED in its speed of sound calculations. The DVL assumes the speed of sound reading is taken at the transducer head. See the primer for information on speed of sound calculations.

NOTE. If the EZ *Transducer Depth* field = 1, the DVL overrides the manually set ED value and uses depth from the internal pressure sensor. If a pressure sensor is not available, the DVL uses the manual ED setting.

EF - Pressure Smoothing Constant

Purpose	Applies an exponential filter to the pressure sensed by the internal pressure sensor.
Format	EFn
Range	n = 1 to 100, (100 disables the filter)
Default	EF100

Recommended Setting. The default setting for this command is recommended for most applications.

Description — The EF command implements an exponential filter for the internal pressure sensor. The effect of this filter is to reduce the single-reading variance. The smoothed pressure value is used in depth calculations and output in the variable leader. It is also available via the PC2 command.

The smoothed value is roughly equivalent to what would be obtained by averaging over a number of measurements: Equivalent number of measurements = (2 - ES/100) / (ES/100)

Since a measurement is made every ping, the equivalent measurement interval is dependent on the TP setting. An EF setting of 100 disables the filter.

NOTE. If there is no internal pressure sensor, this setting has no effect.

EH - Heading

Purpose Sets the DVL heading angle.

Format EH*nnnnn*

Range *nnnnn* = 0 to 35999 (000.00 to 359.99 degrees)

Recommended Setting. Use the EZ-command.

Description EH sets the DVL heading angle of beam 3. When mounted on a stationary platform, the DVL assumes beam 3 points north (0).

Example Convert heading values of 34 and 3.5 to EH-command values.

```
EH = 34.00 × 100 = 3400 = EH03400
EH =  3.50 × 100 =  350 = EH00350
```

NOTE. If the EZ Heading field = one, the DVL overrides the manually set EH value and uses heading from the transducer's internal sensor. If the sensor is not available, the DVL uses the manual EH setting.

EP - Pitch (Tilt 1)

Purpose Sets the DVL pitch (tilt 1) angle.

Format EP±*nnnn*

Range ±*nnnn* = -2000 to 2000 (-20.00 to +20.00 degrees)

Recommended Setting. Use the EZ-command.

Description EP sets the DVL pitch (tilt 1) angle.

Example Convert pitch values of +14 and -3.5 to EP-command values.

```
EP = 14.00 × 100 = 1400 = EP01400 (+ is understood)
EP = -3.50 × 100 = -350 = EP-00350
```

NOTE. If the EZ Pitch field = 1, the DVL overrides the manually set EP value and uses pitch from the transducer's internal tilt sensor. If the sensor is not available, the DVL uses the manual EP setting.

EQ – Enable Single Beam Data

Purpose Output PD0 or PD4 date even when only one beam is good.

NOTE. The EQ command is only available for Navigator DVLs with firmware version 9.19 or higher.

Format EQ*n*

Range n = 0 or 1

Default EQ0

Recommended Setting. The default setting for this command is recommended for most applications.

Description When the EQ command is set to EQ0 (default) the DVL outputs data when three or more beams are good. When the EQ command is set to EQ1, the system will output data in PD0 or PD4 even when only one beam is good. However, the following conditions apply:

1. The system must be in beam coordinates.
2. Single ping only (BP=1)

ER - Roll (Tilt 2)

Purpose Sets the DVL roll (tilt 2) angle.

Format ER±*nnnn*

Range ±*nnnn* = -2000 to 2000 (-20.00 to +20.00 degrees)

Recommended Setting. Use the EZ-command.

Description ER sets the DVL roll (tilt 2) angle.

Example Convert roll values of +14 and -3.5 to ER-command values.

```
ER = 14.00 × 100 = 1400 = ER01400 (+ is understood)
ER = -3.50 × 100 = -350 = ER-00350
```

NOTE. If the EZ Roll field = one, the DVL overrides the manually set ER value and uses roll from the transducer's internal tilt sensor. If the sensor is not available, the DVL uses the manual ER setting.

ES – Salinity

Purpose	Sets the water's salinity value.
Format	ES*nn*
Range	*nn* = 0 to 40
Default	ES35

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description — ES sets the water's salinity value. The Navigator uses ES in its speed of sound calculations. The Navigator assumes the speed of sound reading is taken at the transducer head.

ET - Temperature

Purpose	Sets the water's temperature value.
Format	ET±*nnnn*
Range	±*nnnn* = -500 to 4000 (-5.00 C to +40.00 C)
Default	ET2500

> **Recommended Setting.** Use the EZ-command.

Description — ET sets the temperature value of the water. The DVL uses ET in its speed of sound calculations (see the primer). The DVL assumes the speed of sound reading is taken at the transducer head.

Example — Convert temperatures of +14 C and -3.5 C to ET-command values.

```
ET = 14.00 × 100 = 1400 = ET1400 (+ is understood)
ET = -3.50 × 100 = -350 = ET-0350
```

> **NOTE.** If the EZ Temperature field = one, the DVL overrides the manually set ET value and uses temperature from the transducer's temperature sensor. If the sensor is not available, the DVL uses the manual ET setting.

EX – Coordinate Transformation

Purpose	Sets the coordinate transformation processing flags.
Format	EX*xxptb*
Range	*xx* = Transformation *p* = Pitch and Roll *t* = 3 beam solutions *b* = Bin mapping
Default	EX11111

Recommended Setting. The default setting for this command is recommended for most applications.

Description EX sets firmware switches that control the coordinate transformation processing for velocity and percent-good data.

Table 30: Coordinate Transformation Processing Flags

Setting	Description
EX00xxx	No transformation. Radial beam coordinates, I.E., 1, 2, 3, 4. Heading/Pitch/Roll not applied.
EX01xxx	Instrument coordinates. X, Y, Z vectors relative to the DVL. Heading/Pitch/Roll not applied.
EX10xxx	Ship coordinates (Note 1) Forward, Starboard, Up/Mast vectors relative to the ship. Heading not applied. EA-command used, but not the EB-command. If Bit 3 of the EX-command is a 1, then Pitch/Roll applied.
EX11xxx	Earth coordinates (Note 1) East, North, Vertical vectors relative to Earth. Heading applied. EA and EB-commands used. If Bit 3 of the EX-command is a 1, then Pitch/Roll applied.
EXxx1xx	Use tilts (pitch and roll) in transformation (Note 2)
EXxxx1x	Allows 3-beam solutions if one beam is below the correlation threshold set by WC
EXxxxx1	Allow bin mapping (see Note 4, next page)

NOTES.

1. For ship and earth-coordinate transformations to work properly, you must set the Heading Alignment (EA) and Heading Bias (EB) correctly. You also must ensure that the tilt and heading sensors are active (EZ).

2. Setting EX bit 3 (Use Tilts) to 0 lets you collect tilt data without using it in the ship or earth-coordinate transformations.

3. Each Navigator uses its own beam calibration matrix to correct data for beam pointing errors (e.g., if the beams erroneously point toward 21 degrees instead of 20 degrees). Correction is applied when the data are converted from beam coordinates to earth coordinates. If you output beam-coordinate data, you will need to apply the beam corrections yourself if you want the best possible data or use the *VmDas* software.

Continued next page

4. The DVL outputs Water Profile Bin 1 position for a level system only. We do not adjust the bin 1 position, or the cell sizes, for any tilt. Bin mapping attempts to combine data from sections of the beams that are at the same depth in the water, and does not make any attempt to calculate how that depth that depth might change for a tilted system. The setting of the EX command has no effect on the reported bin 1 distance or the cell size.

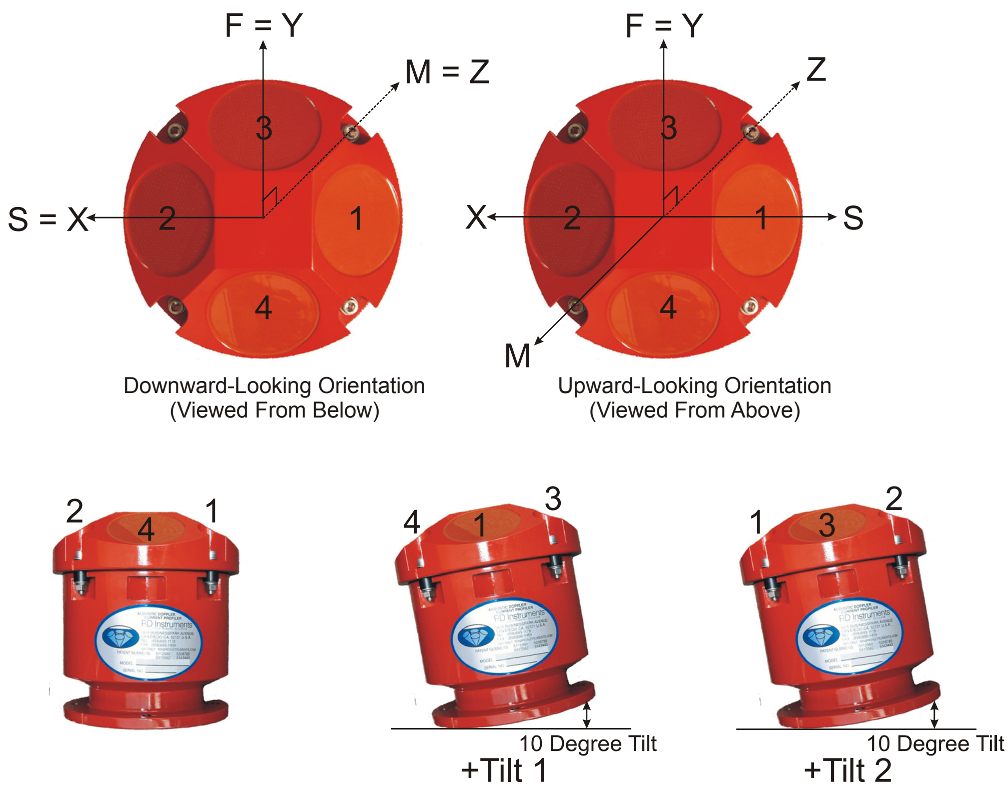


Figure 40. DVL Coordinate Transformation

Sign of Angle for a Unit Facing	Up	Down
Tilt 1 (Pitch) Beam 3 higher than Beam 4	+	+
Tilt 2 (Roll) Beam 2 higher than Beam 1	+	-

EZ - Sensor Source

Purpose Selects the source of environmental sensor data.

Format EZ*cdhprst*

Default EZ1111101

Recommended Setting. The default setting for this command is recommended for most applications.

Range Firmware switches (see description)

Description Setting the EZ-command firmware switches tells the DVL to use data from a manual setting or from an associated sensor. When a switch value is non-zero, the DVL overrides the manual E-command setting and uses data from the appropriate sensor. If no sensor is available, the DVL defaults to the manual E-command setting. The following table shows how to interpret the sensor source switch settings.

Table 31: Sensor Source Switch Settings

	Field	Value = 0	Value = 1	Value = 2	Value = 3
c	Speed Of Sound	Manual EC	Calculate using ED, ES, and ET	N/A	Use SVSS Sensor
d	Depth	Manual ED	Depth Sensor	N/A	N/A
h	Heading	Manual EH	Internal Transducer Sensor	N/A	Use NMEA HDT
p	Pitch (Tilt 1)	Manual EP	Internal Transducer Sensor	N/A	N/A
r	Roll (Tilt 2)	Manual ER	Internal Transducer Sensor	N/A	N/A
s	Salinity	Manual ES	N/A	N/A	N/A
t	Temperature	Manual ET	Internal Transducer Sensor	N/A	N/A

Example EZ1111101 means calculate speed of sound from readings, use pressure sensor, transducer heading, internal tilt sensors, and transducer temperature.

Setting the first parameter of the EZ command to 3 (EZ3xxxxxx) causes the SVSS to be sampled once per ensemble. The speed of sound from the SVSS will be used for all calculations and will be output in the usual place in the variable leader. If there is a problem sampling the SVSS (e.g. communications failure) bit 10 (0400 hex) of the BIT status word will be set and the firmware will calculate the speed of sound as if the first parameter of the EZ command were 1 (EZ1xxxxxx). This is available only for Navigator DVLs systems with firmware version 9.14 or higher.

Setting the third parameter of the EZ command to 3 (EZxx3xxxx) allows the NMEA heading to be used rather than the DVL's internal heading sensor. Please refer to "FSA-017 - Using NMEA Heading Strings," page 334.

11.6 Fault Log Commands

The Navigator uses the following commands to aid in troubleshooting and testing.

11.6.1 Available Fault Log Commands

This section lists the Fault Log commands.

```
>F?
Available Commands:

FC ----------------------- Clear Fault Log
FD ----------------------- Display Fault Log
FX ----------------------- Toggle the Fault Log debug flag
F? ----------------------- Display Fault Log Commands
```

11.6.2 Fault Log Command Descriptions

FC – Clear Fault Log

Purpose Clears the fault log.

Format FC

Recommended Setting. Use as needed.

Description Use this command to clear the fault log of all previous entries.

FD – Display Fault Log

Purpose Displays the fault log.

Format FD

Recommended Setting. Use as needed.

Description Displaying the fault log will list why a built-in test failed. This may aid in troubleshooting.

Example >FD

```
Total Unique Faults   =     2
Overflow Count        =     0
Time of first fault:    97/11/05,11:01:57.70
Time of last fault:     97/11/05,11:01:57.70

Fault Log:
Entry #  0 Code=0a08h  Count=    1  Delta=    0 Time=97/11/05,11:01:57.70
 Parameter = 00000000h
  Tilt axis X over range.
Entry #  1 Code=0a16h  Count=    1  Delta=    0 Time=97/11/05,11:01:57.70
 Parameter = 00000000h
  Tilt Y axis ADC under range.
End of fault log.
```

FX – Toggle the Fault Log Debug Flag

Purpose Toggles the fault log debug flag.

Format FX

Recommended Setting. Use as needed.

Description Use this command to toggle the fault log debug flag.

11.7 Performance and Testing Commands

The Navigator uses the following commands for calibration and testing.

11.7.1 Available Performance and Testing Commands

This section lists the available Performance and Testing commands.

```
>P?
PA ----------------------- Pre-Deployment Tests
PC ### ------------------- Built In Tests, PC 0 = Help
PD = 00 ------------------ Data Stream Select (0-13)
PF ----------------------- Pre-Deployment Tests Summary
PM ----------------------- Distance Measure Facility
PS # --------------------- Show Sys Parms (0=Xdcr,1=FLdr,2=VLdr,3=Mat,4=Seq)
PT ### ------------------- Built In Tests, PT 0 = Help
```

11.7.2 Performance and Testing Command Descriptions

PA – Pre-deployment Tests

Purpose Sends/displays results of a series of Navigator system diagnostic tests.

Format PA

Recommended Setting. Use as needed.

Description These diagnostic tests check the major Navigator modules and signal paths. We recommend you run this command before a deployment. These tests check the following boards/paths.

CPU - CPU RAM and real-time clock.

Recorder - verifies recorder operation.

DSP - RAM, registers, and DSP-to-CPU Communications.

System Tests - A test signal is routed through the DSP and back to the CPU. This checks the main electronics processor path.

Receive Path - quiescent RSSI levels are checked for [20 < RSSI < 60 counts] and the RSSI filters are checked for proper time constants.

Transmit Path - checks transmit voltage, current, and impedance.

Sensors - verifies sensor operation.

Example See next page.

```
>PA
PRE-DEPLOYMENT TESTS
CPU TESTS:
```

```
  RTC.....................................PASS
  RAM.....................................PASS
  ROM.....................................PASS
RECORDER TESTS:
  PC Card #0..............................DETECTED
    Card Detect...........................PASS
    Communication.........................PASS
    DOS Structure.........................PASS
    Sector Test (short)...................PASS
  PC Card #1..............................DETECTED
    Card Detect...........................PASS
    Communication.........................PASS
    DOS Structure.........................PASS
    Sector Test (short)...................PASS
DSP TESTS:
  Timing RAM..............................PASS
  Demod  RAM..............................PASS
  Demod  REG..............................PASS
  FIFOs...................................PASS
SYSTEM TESTS:
  XILINX Interrupts... IRQ3  IRQ3  IRQ3 ...PASS
  Receive Loop-Back.......................PASS
  Wide Bandwidth..........................PASS
  Narrow Bandwidth........................PASS
  RSSI Filter.............................PASS
  Transmit................................PASS
SENSOR TESTS:
  H/W Operation...........................PASS
```

NOTE. Wide Bandwidth and Narrow Bandwidth may fail if transducer is not in water. H/W Operation test will fail if the transducer is on its side.

PC – User-Interactive Built-In Tests

Purpose — Sends/displays results of user-interactive Navigator system diagnostic tests.

Format — PC*nnn*

Range — *nnn* = 0 to 2 (PC0 = Help menu; see below for others)

Recommended Setting. Use as needed.

Description — These diagnostic tests check beam continuity and sensor data. Both tests require user interaction (see examples).

Examples — See below.

PC0 – Help Menu

Sending PC0 displays the help menu.

```
User Interactive, Built In Tests
--------------------------------
PC0 = Help
PC1 = Beam Continuity
PC2 = Sensor Data
```

PC1 – Beam Continuity

Sending PC1 tests the beam continuity by measuring the quiescent Receiver Signal Strength Indicator (RSSI) levels. There must be a change of more than 30 counts when the transducer face is rubbed.

```
BEAM CONTINUITY TEST
When prompted to do so, vigorously rub the selected
beam's face.
If a beam does not PASS the test, send any character to
the DVL to automatically select the next beam.

Collecting Statistical Data...
  52  48  50  43
Rub Beam 1 = PASS
Rub Beam 2 = PASS
Rub Beam 3 = PASS
Rub Beam 4 = PASS
```

PC2 – Display Heading, Pitch, Roll, and Orientation

Sending PC2 displays heading, pitch angle, roll angle, up/down orientation and attitude temperature in a repeating loop at approximately 0.5-sec update rate. Press any key to exit this command and return to the command prompt.

```
Press any key to quit sensor display ...
Heading   Pitch    Roll    Up/Down    Attitude Temp   Ambient Temp  Pressure
301.01°  -7.42°  -0.73°    Up          24.35°C         22.97°C        0.0 kPa
300.87°  -7.60°  -0.95°    Up          24.36°C         22.97°C        0.0 kPa
300.95°  -7.60°  -0.99°    Up          24.37°C         22.97°C        0.0 kPa
300.71°  -7.61°  -0.96°    Up          24.37°C         22.98°C        0.0 kPa
300.69°  -7.61°  -0.96°    Up          24.35°C         22.98°C        0.0 kPa
300.76°  -7.60°  -0.98°    Up          24.38°C         22.97°C        0.0 kPa
```

NOTE. The PC2 heading shows the raw (magnetic north) heading only. The EB command (Heading Bias) is **not** applied.

PD - Data Stream Select

Purpose: Selects the type of ensemble output data structure.

Format: PDn

Range n = 0 to 13 (see description)

CAUTION. While the command line accepts 0 through 13, only 0, 1, 3 - 6, 10, 11, and 13 are actually supported.

Default PD0

Recommended Setting. The default setting for this command is recommended for most applications.

Description: PD selects the normal output data structure, a special application data structure, or a fixed data set for transmission/display as the data ensemble (see Table 32).

Table 32: Data Stream Selections

Format	Description
PD0	This is TRDI's standard format. PD0 is a binary output format. It provides the most information possible including a header, fixed and variable leader, bottom track, and water profile information. The fixed and variable leader is a recording of time, DVL setup, orientation, heading, pitch, roll, temperature, pressure, and self test diagnostic results. Data fields to be output are user selectable.
PD1	Sends an TRDI-defined data set that always uses the same data (except for parts of the leader data). This data set is useful during user-software development.
PD2	Not used.
PD3	PD3 is a binary output format of bottom track speed over the bottom, speed through the water, range to bottom information, and 16 spare bytes with no definition.
PD4	PD4 is a binary output format of bottom track speed over the bottom, speed through the water, and range to bottom information only.
PD5	PD5 is a superset of PD4 and includes information on salinity, depth, pitch, roll, heading, and distance made good.
PD6	PD6 is a text output format. Data is grouped into separate sentences containing system attitude data, timing and scaling, and speed through the water relative to the instrument, vehicle, and earth. Each sentence contains a unique starting delimiter and comma delimited fields.
PD7	Not used
PD8	N/A
PD9	N/A
PD10	PD10 is similar to PD3 but with the addition of pressure and depth fields.
PD11	PD11 is a text output format. It complies with the NMEA 0183 version 2.30 standard.
PD12	N/A
PD13	PD13 is a text output format similar to PD6 with the addition of information about range to bottom and raw pressure sensor data.

NOTE. All of TRDI's software supports PD0 formatted data only.

PF – Pre-Deployment Test Summary

Purpose: Gives a summary of the pre-deployment tests.

Format: PF

Recommended Setting. Use as needed.

Description: The PF command is similar to the PA command, but produces a single line of output that summarizes the same tests performed by the PA command (see "PA – Pre-deployment Tests," page 175).

TEST=A,BCD,EFGHI-JKLMN,PQRS,TUVWXY,Z

Table 33: Pre-Deployment Test Summary BIT Result

Character	Test	Description
A	Performance test overall pass/fail results	Where a zero (0) = something has failed, 1 = all tests passed (refer to PA command). A one (1) will also be produced if the optional hardware is not present
B thru D	CPU Tests	B = RTC CPU Test Results C = RAM CPU Test results D = ROM CPU Test Results Where 0 = test has failed, 1 = test has passed
E thru I	Recorder Test PC Card #0	E = Card detection Status F = Card detect test status G = Communication test status H = DOS structure test status I = Short Sector test status Where 0 = test has failed, 1 = test has passed, X = N/A (no card)
J thru N	Recorder Test, PC Card #1	E = Card detection Status F = Card detect test status G = Communication test status H = DOS structure test status I = Short Sector test status Where 0 = test has failed, 1 = test has passed, X = N/A (no card)
P thru S	DSP Tests	P = Timing RAM test status Q = Demod RAM test status R = Demod REG test status S = FIFOs test status Where 0 = test has failed, 1 = test has passed
T thru Y	System Tests	T = XILINX Interrupts test status U = Receive loop back test status V = Wide Bandwidth test status W = Narrow bandwidth test status X = RSSI filter test status Y = Transmit test status Where 0 = test has failed, 1 = test has passed
Z	Sensor Test	Z = H/W Operation Where 0 = test has failed, 1 = test has passed

PM - Distance Measurement Facility

Purpose Lets you measure distance over the bottom.

Format PM

Recommended Setting. For TRDI use only.

Description PM lets you use the DVL to measure distances over the bottom (horizontal distance that the DVL travels along the path of motion) using a dumb terminal.

PS – Display System Parameters

Purpose	Sends/displays Navigator system configuration data.
Format	PS*n*
Range	*n* = 0, 3 (see description)

Recommended Setting. Use as needed.

Description See below.

PS0 – System Configuration

PS0 sends the Navigator hardware/firmware information. For example, the output may look like this:

```
>ps0
  Instrument S/N:  0
       Frequency:  307200 HZ
   Configuration:  4 BEAM, JANUS
     Match Layer:  10
      Beam Angle:  20 DEGREES
    Beam Pattern:  CONVEX
     Orientation:  DOWN
       Sensor(s):  HEADING  TILT 1  TILT 2  DEPTH  TEMPERATURE  PRESSURE
Pressure Sens Coefficients:
              c3 = +0.000000E+00
              c2 = +0.000000E+00
              c1 = -2.500000E-03
          Offset = +0.000000E+00

Temp Sens Offset:  -0.20 degrees C

    CPU Firmware:  16.xx
   Boot Code Ver:  Required:  1.13   Actual:  1.13
    DEMOD #1 Ver:  ad48, Type:  1f
    DEMOD #2 Ver:  ad48, Type:  1f
    PWRTIMG  Ver:  85d3, Type:   6
Board Serial Number Data:
   08  00 00 02 C9 20 A7  09 CPU727-2000-00H
   4D  00 00 00 D4 97 37  09 PIO727-3000-03C
>
```

PS3 – Instrument Transformation Matrix

PS3 sends information about the transducer beams. The Navigator uses this information in its coordinate-transformation calculations; for example, the output may look like this:

```
ps3
Beam Width:   3.7 degrees

Beam     Elevation     Azimuth
  1         -70.14      269.72
  2         -70.10       89.72
  3         -69.99        0.28
  4         -70.01      180.28

Beam Directional Matrix (Down):
  0.3399    0.0017    0.9405    0.2414
```

```
 -0.3405   -0.0017    0.9403    0.2410
 -0.0017   -0.3424    0.9396   -0.2411
  0.0017    0.3420    0.9398   -0.2415

Instrument Transformation Matrix (Down):    Q14:
  1.4691   -1.4705    0.0078   -0.0067      24069  -24092      127     -109
 -0.0068    0.0078   -1.4618    1.4606       -111     127   -23950    23930
  0.2663    0.2657    0.2657    0.2661       4363    4354     4353     4359
  1.0367    1.0350   -1.0359   -1.0374      16985   16957   -16972   -16996
Beam Angle Corrections Are Loaded.
>
```

If the Navigator needs beam angle corrections, a TRDI calibrated beam angle matrix is loaded into the instrument. This is done when the instrument is manufactured. For more details, request a copy of the ADCP Coordinate Transformation booklet (available for download at www.rdinstruments.com).

PT - Built-In Tests

Purpose Sends/displays results of DVL system diagnostic test.

Format PT*nnn*

Range *nnn* = 0 to 200 (PT0 = Help menu)

Recommended Setting. Use as needed.

Description These diagnostic tests check the major DVL modules and signal paths. Most of the tests give their final results in the format;

```
xxxxxxxxxx TEST RESULTS = $hhhh ... rrrr
```

Where

xxxxxxxxxx = Module or path being tested

$hhhh = Hexadecimal result code ($0 = PASS; see individual tests for description of bit results)

rrrr = Overall test result (“PASS” or “FAIL”)

PT Test Results Error Codes

To find what bits are set when an error occurs, use the following tables.

Table 34: Error Code Hex to Binary Conversion

Hex Digit	Binary	Hex Digit	Binary	Hex Digit	Binary	Hex Digit	Binary
0	0000	**4**	0100	**8**	1000	**C**	1100
1	0001	**5**	0101	**9**	1001	**D**	1101
2	0010	**6**	0110	**A**	1010	**E**	1110
3	0011	**7**	0111	**B**	1011	**F**	1111

To convert error code $32CF (note: the dollar sign “$” signifies hexi-decimal), convert 32CF to binary. Error code $32CF has the following bits set: 13, 12, 9, 7, 6, 3, 2, 1, 0.

Hex Digit $	3				2				C				F			
Binary	0	0	**1**	**1**	0	0	**1**	0	**1**	**1**	0	0	**1**	**1**	**1**	**1**
Bit #	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

PT0 - Help

Displays the test menu (shown below). As implied by the NOTE, adding 100 to the test number repeats the test continually until the DVL receives a <BREAK>. Sending PT200 runs all tests. PT300 runs all tests continually until the DVL receives a <BREAK>.

```
>PT0
Built In Tests
----------------
PT0 = Help
PT1 = NA
PT2 = Ancillary System Data
PT3 = Receive Path
PT4 = Transmit Path
PT5 = Electronics Wrap Around
PT6 = Receive Bandwidth
PT7 = RSSI Bandwidth
NOTE: Add 100 for automatic test repeat
PT200 = All tests
```

PT2 - Ancillary System Data

This test displays the values for ambient and attitude temperature and the contamination sensor (TRDI use only). The ambient temperature is measured on the receiver board. This sensor is imbedded in the transducer head, and is used for water temperature reading. The attitude temperature is measured on the PIO board under the compass. If one of the sensors fails, the PC2 test will show both sensors at the same value. The DVL will use the attitude temperature if the ambient temperature sensor fails. A reading ≥+55° may indicate a shorted sensor, and a reading ≥-32° may indicate an open sensor.

```
>PT2
  Ambient  Temperature =    21.10 Degrees C
  Attitude Temperature =    21.39 Degrees C
  Internal Moisture    = 8D50h
```

PT3 - Receive Path

This test displays receive path characteristics. The test result is given as eight nibbles (1 nibble = 4 bits). Each nibble represents the result for a particular beam (most significant nibble = beam 1, least significant nibble = beam 8) (four beam DVLs utilize the four most significant nibbles). In this example, we only describe which bit is set for beam 2 for a given failure type. This test has three parts.

Part 1 - The DVL pings without transmitting and displays the result of an autocorrelation function performed over 14 lag periods (only the first 8 are displayed). Ideally, we should see high correlation at near-zero lags, and then see decorrelation as the lags get longer. High correlation values at longer lags indicate interference is present.

Part 2 - The DVL compares the RSSI value at high gain versus low gain. These values give the noise floor for RSSI. A high noise floor indicates possible interference or a hardware problem. A low difference between high and low RSSI values can indicate a problem in the demodulator, receiver, or RSSI switching circuitry.

Part 3 - The DVL displays the demodulator DAC values.

```
>PT3

Correlation Magnitude: Wide Bandwidth

               Lag  Bm1  Bm2  Bm3  Bm4
                 0  255  255  255  255
                 1  169  175  167  179
                 2   49   55   54   58
                 3   26   20   19    8
                 4   20   17   24   29
                 5   14   13   14   23
                 6    8    4   13    8
                 7    6    1   10    1

  High Gain RSSI:    43   41   40   42
   Low Gain RSSI:    19   19   17   18

  SIN Duty Cycle:    52   50   52   51
  COS Duty Cycle:    49   50   51   51

Receive Test Results = $0000 .... PASS
```

PT3 failure description - You can determine beam failure results ($>0, see “PT Test Results Error Codes,” page 181) by the individual bit settings:

Table 35: PT3 Failure

Bit #	PT3 Failure Description
0	Low Correlation – Correlation at lag 1 is <70% (130 counts).
1	High Correlation - A correlation at lag 7 or above is >63 counts.
2	High Noise Floor - Noise floor for high gain is >59.
3	Low Differential Gain – Noise floor difference between high and low gains is less than 5 dB (10 counts).

NOTE. A functional DVL may fail high correlation or high noise floor when this test is run in air due to interference. This test should be run in the deployed environment to achieve good results.

PT4 - Transmit Path

This test displays transmit path characteristics. During the test, the DVL pings and measures the resulting transmit current and voltage. For example:

```
>PT4
IXMT    =      2.0 Amps rms
VXMT    =     74.0 Volts rms
   Z    =     37.6 Ohms
Transmit Test Results = $0 ... PASS
```

NOTE. The DVL should be in water during this test to get valid test results.

PT4 failure description - You can determine failure results ($>0 see "PT Test Results Error Codes," page 181) by the individual bit settings:

Table 36: PT4 Failure

Bit #	PT4 Failure Description
0	ADC TIMEOUT ERROR - The DSP Board ADC was not ready for reading when the CPU was ready to read the ADC.
1	TRANSMIT TIMEOUT - The DSP Board never indicated completion of transmission.
2	SAMPLE TIMEOUT - The DSP Board never indicated completion of sampling.
3	LCA REGISTERS CORRUPTED - The DSP Board timing registers lost their value after pinging.
4	OVER-CURRENT SHUTDOWN
5	OVER-TEMPERATURE SHUTDOWN
6	INCORRECT TRANSDUCER IMPEDANCE - Impedance (Vxmt / Ixmt) was too high (>200Ω) or too low (<20Ω).
7	LOW TRANSMIT VOLTS AND/OR CURRENT - Transmit voltage was too low (Vxmt <10V) and/or transmit current too low (Ixmt <0.1A).

NOTE. Transducer should be in water when running this test.

The test failure example shown below is what you would see for a missing or improperly attached transmit cable (see "Troubleshooting," page 90).

```
>pt4

IXMT    =      0.0 Amps rms  [Data= 0h]
VXMT    =     19.3 Volts rms [Data=4ch]
   Z    =    999.9 Ohms
Transmit Test Results = $C0 ... FAIL
>
```

PT5 - Electronics Wrap Around

This test sets up the DVL in a test configuration in which the test output lines from the DSP Board timing generator are routed directly to the Receiver board. The receiver then processes this signal. The test output signal sends a certain correlation pattern when processed. The ideal pattern is as follows.

```
  0   0   0   0
  0   0   0   0
  0   0   0   0
  0   0   0   0
255 255 255 255
  0   0   0   0
  0   0   0   0
255 255 255 255
  0   0   0   0
  0   0   0   0
  0   0   0   0
255 255 255 255
```

Acceptable deviations from this pattern are due to deviations in sampling bandwidth and demodulator low-pass filter bandwidth variations. For example:

```
>PT5
13  13  13  13
13  13  13  13
13  13  13  13
0   0   0   0
255 255 255 255
13  13  13  13
0   0   0   0
255 255 255 255
13  13  13  13
13  13  13  13
0   0   0   0
255 255 255 255
Electronics Test Results = $0000
```

PT5 results description - Test failures indicate possible problems with the Receiver or DSP boards. You can determine failure results ($>0 see “PT Test Results Error Codes,” page 181) by the individual bit settings:

Table 37: PT5 Results

Bit #	PT5 Results Description
28	BEAM 1 STATUS - A high value (normally 255) was <254, or a low value (normally 0) was >20.
24	BEAM 2 STATUS - See Bit 28.
20	BEAM 3 STATUS - See Bit 28.
16	BEAM 4 STATUS - See Bit 28.
12	BEAM 5 STATUS - See Bit 28.
ALL	RECEIVER TIMEOUT – The CPU never received a “processing done” signal from the receiver.

PT6 - Receive Bandwidth

This test measure the receive bandwidth of the system. The bandwidth varies with system frequency and the WB command setting.

```
>PT6
Receive Bandwidth:
    Sample      bw    bw    bw    bw    bw
      rate  expect   Bm1   Bm2   Bm3   Bm4
       307     120    91    93    88    88 Khz
   results          PASS  PASS  PASS  PASS
```

NOTE. The DVL should be in water during this test to get valid test results.

Table 38: PT6 Receive Bandwidth Nominal Values

Bandwidth setting	WB command	150kHz	300 kHz	600 kHz	1200 kHz
Broad	0	45	79	200	316
Narrow	1	12	14	40	112

NOTE. Beam fails if <50% or >125% of nominal value.

PT7 - RSSI Bandwidth

This test checks the RSSI filter circuits are working. Values listed are the indicated RSSI sampled at 1-ms intervals after a "listen" ping.

```
>PT7
RSSI Time Constant:

RSSI Filter Strobe 1 =   38400 Hz
  time   Bm1   Bm2   Bm3   Bm4
  msec  cnts  cnts  cnts  cnts
     1     6     6     7     8
     2    11    12    14    15
     3    15    16    19    20
     4    20    21    23    25
     5    23    24    27    28
     6    26    27    30    31
     7    28    29    32    33
     8    30    31    34    35
     9    32    33    36    37
    10    34    35    37    38
   nom    43    43    42    43

result    PASS  PASS  PASS  PASS
>
```

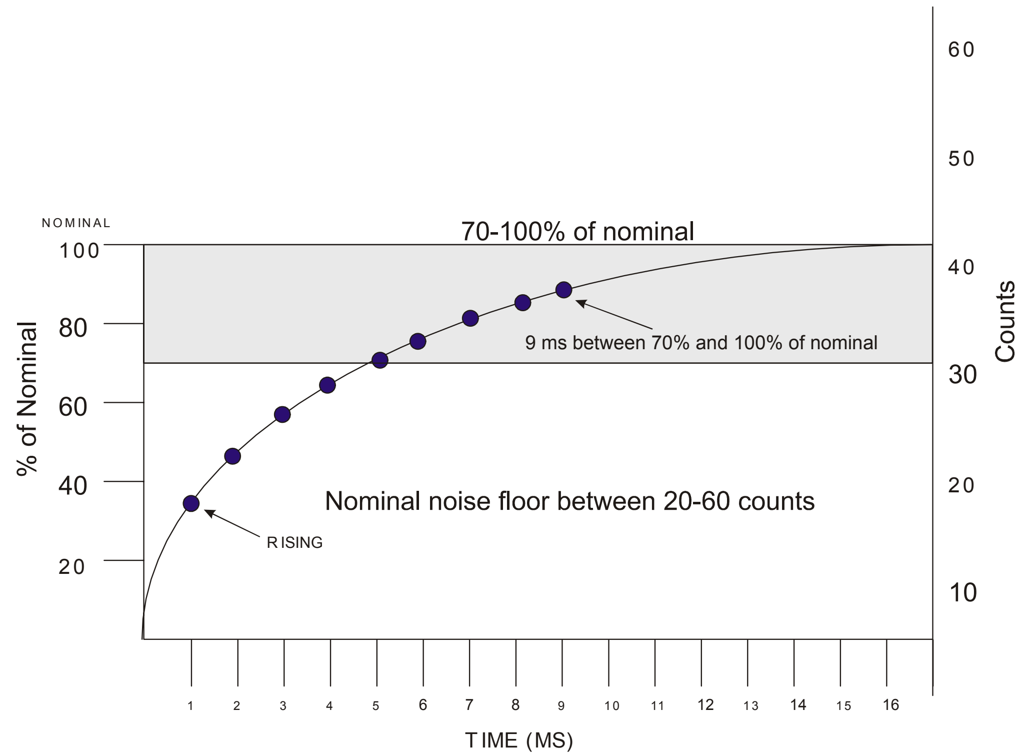


Figure 41. PT7 RSSI Bandwidth Test

Criteria for failure. Any one of the following conditions will flag failure for the beam:

Nominal noise floor <20 or >60

Counts for ms 1 through 4 not rising

9th ms sample not between 70 and 100% of nominal counts

11.8 Recorder Commands

The following paragraphs list all the Navigator recorder commands.

NOTE. Navigator DVLs do not include a memory card. Two PCMCIA memory card slots are available, with the total memory capacity not to exceed 2GB.

11.8.1 Available Recorder Commands

This section lists the available Recorder commands.

```
>r?
Available Commands:

RA ----------------------- Number of Deployments Recorded
RB ----------------------- Recorder Built-In-Test
RE ----------------------- Recorder Erase
RF ----------------------- Recorder Space used/free (bytes)
RN        ---------------- Set Deployment Name
RR ----------------------- Recorder directory
RS ----------------------- Recorder Space used/free (Mb)
RY ----------------------- Upload Recorder Files to Host
R? ----------------------- Display Recorder Commands
```

11.8.2 Recorder Command Descriptions

RA - Number of Deployments

Purpose Shows the number of deployments recorded on the internal recorder.

Format RA

Recommended Setting. Use as needed.

Description RA lists the number of deployments recorded on the optional internal recorder.

RB - Recorder Built-In Test

Purpose Tests the recorder.

Format RB

Recommended Setting. Use as needed. The recorder test is included in the PA command.

Description RB tests the recorder RAM, detects the number of memory cards, checks communication, and checks recorder functions using non-destructive methods.

Example See below.

```
>rb
RECORDER TESTS:
  PC Card #0..............................NOT DETECTED
  PC Card #1..............................DETECTED
    Card Detect...........................PASS
    Communication.........................PASS
    DOS Structure.........................PASS
    Sector Test (Short)...................PASS

Recorder tests complete.
```

RE – Erase Recorder

Purpose Erases/initializes recorder memory.

Format RE ErAsE

Description RE ErAsE erases the recorder memory. This command *is* case sensitive.

Recommended Setting. Use as needed.

Example See below.

```
>RE ErAsE
[ERASING...]
```

RF – Recorder Free Space (Bytes)

Purpose Lists the amount of used and free recorder space in bytes.

Format RF

Description RF lists the amount of recorder space used and free in bytes.

Recommended Setting. Use as needed.

Example See below

```
>RF
RF = 0,10407936 -------- REC SPACE USED (BYTES), FREE (BYTES)
```

This shows the Navigator contains a 10-MB recorder.

RN – Set Deployment Name

Purpose Sets the deployment name used for future deployments.

Format RN AAAAA

Default RN _RDI_

Recommended Setting. Use as needed.

Description RN sets the deployment name to be used for any future deployments. The deployment name must be exactly five characters in length, and may contain letters, numbers, or the underscore (i.e. "_") character. If no deployment name is specified, a default of "_ RDI_" is used. The deployment name is used as part of the DOS file name for data files stored on the recorder. For example, the file "_RDI_000.000" would contain data for the first deployment named "_RDI_" (the 000 in the filename indicates the first deployment). The ".000" file extension indicates that this is the first file in the deployment sequence. A ".001" extension will be used if the deployment spills over onto the second PCMCIA card in the recorder. Each PCMCIA card is set up as a separate DOS disk drive with its own DOS file structure. Deployments that are recorded completely on a single PCMCIA device will only have the ".000" file extension.

RR – Show Recorder File Directory

Purpose Lists the files on the recorder in the style of a DOS directory listing.

Format RR

> **Recommended Setting.** Use as needed.

Description RR lists the files stored on the recorder in the form of a DOS directory listing. Each PCMCIA device is listed as a separate drive.

RS - Recorder Free Space (Megabytes)

Purpose Lists the amount of used and free recorder space in megabytes.

Format RS

> **Recommended Setting.** Use as needed.

Description RS lists the amount of recorder space used and free in megabytes.

Example See below

```
>RS
RS = 000,010 -------- REC SPACE USED (MB), FREE (MB)
```

This shows the Navigator contains a 10-MB recorder.

RY – Upload Recorder Files

Purpose	Uploads recorder data to a host computer using standard YMODEM protocol.
Format	RY

> **Recommended Setting.** Use as needed.

Description RY uploads the entire contents of the recorder via the serial interface to a host computer using the standard YMODEM protocol for binary file transfer. Any communications program that uses the YMODEM protocol may be used to upload the recorder data. The data is transferred to the host and stored as binary files. This command may be used to recover deployment data without opening the pressure case of the Navigator unit.

Alternatively, the PCMCIA recorder cards may be removed from the unit and placed into a PCMCIA slot in any MS-DOS based computer so equipped. The data files may then be accessed in the same manner as from any other disk drive.

> **CAUTION.** Do not use Windows® to erase the files on the PCMCIA card. Windows® sometimes creates hidden files, which will cause issues for the DVL at the next deployment. Place the PCMCIA card in the DVL and use the RE command to erase the card.

11.9 Ping Synchronization Commands

The Teledyne RD Instruments Sleepy Sensor Synchronization (RDS^3) protocol allows a Navigator to synchronize measurements with another Navigator or any other instrument that adheres to the RDS^3 specification.

11.9.1 Available Ping Synchronization Commands

This section lists the available Ping Synchronization commands.

```
>S?
SA = 000 ----------------- Synch Before/After Ping/Ensemble Bottom/Water/Both
SI = 00000 --------------- Synch Interval (0-65535)
SM = 0 ------------------- Mode Select (0=OFF,1=MASTER,2=SLAVE)
SS = 0 ------------------- RDS3 Sleep Mode (0=No Sleep)
ST = 00000 --------------- Slave Timeout (seconds,0=indefinite)
SW = 00000 --------------- Synch Delay (1/10 msec)
```

11.9.2 Ping Synchronization Command Descriptions

SA - Synchronize Before/After Ping/Ensemble

Purpose	Sets the rough timing of the synchronization pulse.
Format	SA*xyz*
Range	*x* = 0, 1 *y* = 0, 1 *z = 0, 1, 2*
Default	SA001

Recommended Setting. Special applications only.

Description	Use the SA command to set the rough timing of the synchronization pulse. The first parameter determines whether the Master (or Slave) will send (or wait for) a synchronization pulse before or after the conditions set in parameters y and z. If the second parameter is set to Ping, the third parameter determines what kind of ping to synchronize on. If parameter y is set to Ensemble, the third parameter is ignored (but must still be entered).

Table 39: Synchronization Parameters

Parameter	Description
SA000	Send (wait for) pulse before a bottom ping.
SA001	Send (wait for) pulse before a water ping.
SA002	Send (wait for) pulse before both pings
SA100	Send (wait for) pulse after a bottom ping.
SA101	Send (wait for) pulse after a water ping.
SA102	Send (wait for) pulse after both pings.
SA01X	Send (wait for) pulse before ensemble.
SA11X	Send (wait for) pulse after ensemble.

NOTE. This command has no effect unless SM = 1 or 2.

SI - Synchronization Interval

Purpose Sets how many pings/ensembles to wait before sending the next synchronization pulse.

Format SI*nnnnn*

Range *nnnnn* = 0 to 65535

Default SI0

Recommended Setting. Special applications only.

Description Use the SI command to set how many pings/ensembles (depending on the SA command) to wait before sending the next synchronization pulse.

NOTE. This command has no effect unless SM = 1

SM - RDS3 Mode Select

Purpose Sets the RDS3 Mode.

Format SM*n*

Range *n* = 0 (Off), 1 (RDS3 Master), 2 (RDS3 Slave), 3 (NEMO)

Default SM0

Recommended Setting. Special applications only.

Description SM sets the RDS3 Mode. SM0 turns off the RDS3 mode and disables all other commands on this menu. SM1 sets the RDS3 Master mode and enables the SA, SI, SS, and SW commands. SM2 sets the RDS3 Slave mode and enables the SA, SS, and ST commands. SM3 sets the NEMO Mode and enables the SW command.

NOTE. When the SM command is used, the communication switch on the DVL's PIO board must be in the RS232 position.

SS - RDS3 Sleep Mode

Purpose Sets the RDS3 Sleep Mode.

Format SS*x*

Range *x* = 0, 1 (0 = No Sleep, 1 = Sleep)

Default SS0

Recommended Setting. The default setting for this command is recommended for most applications.

Description This command sets the RDS3 Sleep Mode. When x is set to No Sleep, the instrument remains awake while waiting for the next ping time (or synchronization pulse) in a loop. When x is set to Sleep, the instrument sleeps between pings (or synchronization pulses.) There are limitations to using the Sleep Mode. An TRDI WorkHorse, setup as a slave, can only synchronize to within 2.5 ms of the Master. When the Slave is in No Sleep Mode, the slave can ping to within 500 microseconds of the master. The benefits of power saving cost are synchronization accuracy.

Table 40: Sleep Mode Parameters

Parameter	Description
SS0	Wait between pings (synchronization pulses) in a loop.
SS1	Wait between pings (synchronization pulses) in a sleep state.

NOTE. This command has no effect unless SM = 1 or 2

ST - Slave Timeout

Purpose Sets the amount of time a slave will wait to hear a synch pulse before proceeding on it's own.

Format ST*n*

Range n = 0 to 10800 seconds

Default ST0

Recommended Setting. Special applications only.

Description ST sets the amount of time a slave will wait to hear a synch pulse before proceeding on its own. If a slave times out, it will automatically ping according to the CF, TP, TE, WP, and BP command settings. This is a fail-safe mechanism designed to allow the slave to proceed on it's own should communications with the master DVL fail. Setting ST = 0 tells the slave to wait indefinitely.

NOTE. This command has no effect unless SM = 2

SW - Synchronization Delay

Purpose Sets the amount of time to wait after sending the pulse.

Format SW*n*

Range n = 0 to 65535 (units of 0.1 milliseconds)

Default SW00075

Recommended Setting. The default setting for this command is recommended for most applications.

Description Use the SW command to set the amount of time to wait after sending the pulse before proceeding. For example, setting the SW command to SW20000 will add a delay of 2 seconds. This allows precise timing of measurements.

When a Master attempts to ping a slave DVL, it sends out a pulse to the slave DVL. The slave DVL has a different code path than the Master DVL and thus, they will take different amounts of time to start the ping. By adding in the default Master Delay of 7.5 ms, the code paths are evened up to allow the units to start the pings at about the same time (typically within 100 microseconds of each other).

NOTE. This command has no effect unless SM = 1 or 3

11.10 Timing Commands

These commands let you set the timing of various profiling functions.

11.10.1 Available Timing Commands

This section lists the available Timing commands.

```
>T?
TB = 00:00:00.00 --------- Time per Burst (hrs:min:sec.sec/100)
TC = 00000 --------------- Ensembles Per Burst (0-65535)
TE = 00:00:01.00 --------- Time per Ensemble (hrs:min:sec.sec/100)
TF = **/**/**,**:**:** --- Time of First Ping (yr/mon/day,hour:min:sec)
TG = ****/**/**,**:**:** - Time of First Ping (CCYY/MM/DD,hh:mm:ss)
TP = 00:00.00 ------------ Time per Ping (min:sec.sec/100)
TS = 05/08/29,14:39:27 --- Time Set (yr/mon/day,hour:min:sec)
TT = 2005/08/29,14:39:27 - Time Set (CCYY/MM/DD,hh:mm:ss)
```

11.10.2 Timing Command Descriptions

TB - Time Per Burst

Purpose	Sets the interval between “bursts” of pings.
Format	TB hh:mm:ss.ff
Range	hh = 00 to 23 hours mm = 00 to 59 minutes ss = 00 to 59 seconds ff = 00 to 59 hundredths of seconds

Recommended Setting. Special applications only.

Description	The TB and TC commands work together to allow the DVL to sample in a “burst mode.” In some applications, it is desirable for the DVL to ping for a short period of time at a high ping rate (“burst”), wait for a set period of time, and then repeat the process. You also must set the time per ensemble, time between pings, and number of pings per ensemble.
Example	Deployment timing example:

```
TB 01:00:00.00   (time per burst)
TC 20            (ensembles per burst)
TE 00:00:01.00   (time per ensemble)
TP 00:00.20      (time between pings)
WP 2             (pings per ensemble)
```

The DVL will average two pings (WP-command) 0.2 seconds apart (TP-command). It then sends the ensemble to the recorder or through the I/O cable. This process is repeated once a second (TE-command) for a total of twenty ensembles (TC-command). After the 20th ensemble is processed, the DVL sleeps for one hour (TB-command) from the time of the first ping of the first ensemble until the second burst begins.

TC - Ensemble Per Burst

Purpose	Sets the number of ensembles per burst.
Format	TC*nnnnn*
Range	0 to 65535 ensembles per burst
Default	TC0

Recommended Setting. Special applications only.

Description	Setting TC to zero disables the burst mode (i.e., TB-command inactive). See the TB-command for details on how these two commands interact.

TE – Time Per Ensemble

Purpose	Sets the minimum interval between data collection cycles (data ensembles).
Format	TE*hh:mm:ss.ff*
Range	*hh* = 00 to 23 hours *mm* = 00 to 59 minutes *ss* = 00 to 59 seconds *ff* = 00 to 99 hundredths of seconds
Default	TE00:00:01.00

Recommended Setting. Set using *PlanADCP*, *VmDas*, or *WinRiver*.

Description	During the ensemble interval set by TE, the Navigator transmits the number of pings set by the WP-command. If TE = 00:00:00.00, the Navigator starts collecting the next ensemble immediately after processing the previous ensemble.
Example	TE01:15:30.00 tells the Navigator to collect data ensembles every 1 hour, 15 minutes, 30 seconds.

NOTES.

1. The Navigator automatically increases TE if (WP x TP > TE).
2. The time tag for each ensemble is the time of the first ping of that ensemble.

TF – Time of First Ping

Purpose: Sets the time the Navigator wakes up to start data collection.

Format: TF*yy/mm/dd, hh:mm:ss*

Range:
yy = year 00-99
mm = month 01-12
dd = day 01-31 (leap years are accounted for)
hh = hour 00-23
mm = minute 00-59
ss = second 00-59

Recommended Setting. Set using *PlanADCP*.

Description: TF delays the start of data collection. This lets you deploy the Navigator in the Standby mode and have it automatically start data collection at a preset time (typically used in battery operated instruments). When the command is given to the Navigator to start pinging, TF is tested for validity. If valid, the Navigator sets its alarm clock to TF, goes to sleep, and waits until time TF before beginning the data collection process.

Example: If you want the exact time of the first ping to be on November 23, 1992 at 1:37:15 pm, you would enter TF92/11/23, 13:37:15. If you want the Navigator to begin pinging immediately after receiving the CS-command (see notes), do not enter a TF-command value.

NOTES.

1. Although you may send a TF-command to the Navigator, you also must send the CS-command before deploying the Navigator.
2. If the entry is not valid, the Navigator sends an error message and does not update the wake-up time.
3. Sending a <BREAK> clears the TF time.

TG – Time of First Ping (Y2k Compliant)

Purpose Sets the time the Navigator wakes up to start data collection.

Format TG*ccyy/mm/dd, hh:mm:ss*

Range

cc	= century 19 - 20
yy	= year 00 - 99
mm	= month 01 - 12
dd	= day 01 - 31 (leap years are accounted for)
hh	= hour 00 - 23
mm	= minute 00 - 59
ss	= second 00 – 59

Recommended Setting. Set using *PlanADCP*.

Description TG delays the start of data collection. This lets you deploy the Navigator in the Standby mode and have it automatically start data collection at a preset time (typically used in battery operated instruments). When the command is given to the Navigator to start pinging, TG is tested for validity. If valid, the Navigator sets its alarm clock to TG, goes to sleep, and waits until time TG before beginning the data collection process.

Example If you want the exact time of the first ping to be on November 23, 2000 at 1:37:15 pm, you would enter TG 2000/11/23, 13:37:15. If you want the Navigator to begin pinging immediately after receiving the CS-command (see notes), do not enter a TG -command value.

NOTES.

1. Although you may send a TG -command to the Navigator, you also must send the CS-command before deploying the Navigator.
2. If the entry is not valid, the Navigator sends an error message and does not update the wake-up time.
3. Sending a <BREAK> clears the TG time.

TP – Time Between Pings

Purpose Sets the *minimum* time between pings.

Format TP*mm:ss.ff*

Range

mm	= 00 to 59 minutes
ss	= 00 to 59 seconds
ff	= 00 to 99 hundredths of seconds

Default TP00:00.00

Recommended Setting. Set using *PlanADCP*, *VmDas*, or *WinRiver*.

Description The Navigator interleaves individual pings within a group so they are evenly spread throughout the ensemble.

During the ensemble interval set by TE, the Navigator transmits the number of pings set by the WP-command. TP determines the spacing between the pings. If TP = 0, the Navigator pings as quickly as it can based on the time it takes to transmit each ping plus the overhead that occurs for processing. Several commands determine the actual ping time (WF, WN, WS, and actual water depth).

Example TP00:00.10 sets the time between pings to 0.10 second.

NOTE. The Navigator automatically increases TE if (WP x TP) > TE.

TS – Set Real-Time Clock

Purpose Sets the Navigator's internal real-time clock.

Format TS*yy/mm/dd, hh:mm:ss*

Range
yy = year 00-99
mm = month 01-12
dd = day 01-31
hh = hour 00-23
mm = minute 00-59
ss = second 00-59

Recommended Setting. Set using *BBTalk*, *PlanADCP*, *VmDas*, or *WinRiver*.

Example TS98/06/17, 13:15:00 sets the real-time clock to 1:15:00 pm, June 17, 1998.

NOTES.

1. When the Navigator receives the carriage return after the TS-command, it enters the new time into the real-time clock and sets hundredths of seconds to zero.

2. If the entry is not valid, the Navigator sends an error message and does not update the real-time clock.

TT – Set Real-Time Clock (Y2k Compliant)

Purpose	Sets the Navigator's internal real-time clock.
Format	TT*ccyy/mm/dd, hh:mm:ss*
Range	*cc* = century 19 - 20 *yy* = year 00 - 99 *mm* = month 01 - 12 *dd* = day 01 - 31 *hh* = hour 00 - 23 *mm* = minute 00 - 59 *ss* = second 00 - 59

Recommended Setting. Set using *PlanADCP*, *VmDas*, or *WinRiver*.

Example	TT2000/06/17, 13:15:00 sets the real-time clock to 1:15:00 pm, June 17, 2000.

NOTES.

1. When the Navigator receives the carriage return after the TS-command, it enters the new time into the real-time clock and sets hundredths of seconds to zero.

2. If the entry is not valid, the Navigator sends an error message and does not update the real-time clock.

11.11 Water Profiling Commands

These commands define the criteria used to collect the water-profile data.

NOTE. Water Profiling is a feature upgrade for Navigator DVLs (see "Feature Upgrades," page 121). Contact TRDI for information on how to install Water Profiling capability in your Navigator.

11.11.1 Available Water Profiling Commands

This section lists the available Water Profiling commands.

```
>W?
WA = 050 ----------------- False Target Threshold (Max) (0-255 counts)
WB = 0 ------------------- Bandwidth Control (0=Wid,1=Nar)
WC = 064 ----------------- Correlation Threshold
WD = 111 100 000 --------- Data Out (Vel;Cor;Amp  PG;St;P0  P1;P2;P3)
WE = 1000 ---------------- Error Velocity Threshold (0-5000 mm/s)
WF = 0044 ---------------- Blank After Transmit (cm)
WI = 0 ------------------- Clip Data Past Bottom (0=OFF,1=ON)
WJ = 1 ------------------- Rcvr Gain Select (0=Low,1=High)
WL = 001,005 ------------- Water Reference Layer:  Begin Cell (0=OFF), End Cell
WN = 030 ----------------- Number of depth cells (1-128)
WP = 00000 --------------- Pings per Ensemble (0-16384)
WQ = 0 ------------------- Sample Ambient Sound (0=OFF,1=ON)
WS = 0100 ---------------- Depth Cell Size (cm)
WT = 0000 ---------------- Transmit Length (cm) [0 = Bin Length]
WV = 175 ----------------- Mode 1 Ambiguity Vel (cm/s radial)
```

11.11.2 Water Profiling Command Descriptions

WA - False Target Threshold Maximum

Purpose	Sets a false target (fish) filter.
Format	WA*nnn*
Range	*nnn* = 0 to 255 counts (255 disables this filter)
Default	WA050

Recommended Setting. The default setting for this command is recommended for most applications.

Description The DVL uses the WA-command to screen water-track data for false targets (usually fish). WA sets the maximum difference between echo intensity readings among the four profiling beams. If the WA threshold value is exceeded, the DVL rejects velocity data on a cell-by-cell basis for either the affected beam (fish detected in only one beam) or for the affected cell in all four beams (fish detected in more than one beam). This usually occurs when fish pass through one or more beams.

NOTE. A WA value of 255 turns off this feature.

WB - Mode 1 Bandwidth Control

Purpose — Sets profiling mode 1 bandwidth (sampling rate). Smaller bandwidths allow the DVL to profile farther, but the standard deviation is increased by as much as 2.5 times.

Format — WB*n*

Range — *n* = 0 (Wide), 1 (Narrow)

Default — WB0

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description — See table below.

Table 41: Bandwidth Control

Bandwidth	Sample rate	Data variance	Profiling range
0 = Wide (25%)	High	Low	Low
1 = Narrow (6.25%)	Low	High	High

WC - Low Correlation Threshold

Purpose — Sets the minimum threshold of water-track data that must meet the correlation criteria.

Format — WC*nnn*

Range — *nnn* = 0 to 255 counts

Default — WC64

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description — The DVL uses WC to screen water-track data for the minimum acceptable correlation requirements. The nominal (maximum) correlation depends on system frequency and depth cell size (WS). WC sets the threshold of the correlation below, which the DVL flags the data as bad and does not average the data into the ensemble.

> **NOTE.** The default threshold for all frequencies is 64 counts. A solid target would have a correlation of 255 counts.

WD – Data Out

Purpose Selects the data types collected by the DVL.

Format WD *abc def ghi*

Range Firmware switches (see description)

Default WD 111 100 000

Recommended Setting. The default setting for this command is recommended for most applications.

Description WD uses firmware switches to tell the DVL the types of data to collect. The DVL always collects header data, fixed and variable leader data, and checksum data. Setting a bit to one tells the DVL to collect that data type. The bits are described as follows:

a = Velocity	*d* = Percent good	*g* = Reserved
b = Correlation	e = Status	*h* = Reserved
c = Echo Intensity	*f* = Reserved	*I* = Reserved

Example WD 111 100 000 (default) tells the DVL to collect velocity, correlation magnitude, echo intensity, and percent-good.

NOTES.

1. Each bit can have a value of one or zero. Setting a bit to one means output data, zero means suppress data.
2. If WP = zero, the DVL does not collect water-profile data.
3. Spaces in the command line are allowed.
4. Status data is not used, as it does not mean anything.

WE - Error Velocity Threshold

Purpose Sets the maximum error velocity for good water-current data.

Format WE*nnnn*

Range *nnnn* = 0 to 5000 mm/s

Default WE2000

CAUTION. The default setting is set purposely high. We recommend extreme caution and testing before changing this setting. **Data rejected by this command is lost and cannot be regained.**

Description The WE-command sets a threshold value used to flag water-current data as good or bad. If the DVL's error velocity value exceeds this threshold, it flags data as bad for a given depth cell. The WE command screens for error velocities in both beam and transformed-coordinate data. Setting the WE command to zero (WE0) disables error velocity screening.

WF – Blank after Transmit

Purpose	Moves the location of first depth cell away from the transducer head to allow the transmit circuits time to recover before the receive cycle begins.
Format	WF*nnnn*
Range	*nnnn* = 0 to 9999 cm
Default	WF0704 (75kHz), WF0352 (150kHz), WF0176 (300kHz), WF0088 (600kHz), WF0044 (1200kHz)

Recommended Setting. The default setting for this command is recommended for most applications.

Description — WF positions the start of the first depth cell at some vertical distance from the transducer head. This allows the Navigator transmit circuits time to recover before beginning the receive cycle. In effect, WF blanks out bad data close to the transducer head, thus creating a depth window that reduces unwanted data in the ensemble.

NOTES.

1. The distance to the middle of depth cell #1 is a function of blank after transmit (WF), depth cell size (WS), and speed of sound. The fixed leader data contains this distance.

2. Small WF values may show ringing/recovery problems in the first depth cells that cannot be screened by the Navigator.

WI - Clip Data Past Bottom

Purpose	Allows the DVL to flag velocity data from beyond the bottom as bad.
Format	WIn
Range	n = 0 (off), 1 (on)
Default	WI0

Recommended Setting. The default setting for this command is recommended for most applications.

Description — When the WI-command is set to WI0 (default), the DVL sends/records all velocity data readings even when the DVL determines the data is beyond the bottom. WI1 tells the DVL to flag data determined to be beyond the bottom as bad (data value set to -32768 [8000h]).

WJ - Receiver Gain Select

Purpose	Allows the DVL to reduce receiver gain by 40 dB.
Format	WJn
Range	n = 0 (low), 1 (high)
Default	WJ1

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description WJ0 tells the DVL to reduce receiver gain by 40 dB. This may increase data reliability in shallow-water applications where there is a high content of backscatter material. WJ1 (the default) uses the normal receiver gain.

WL - Water Reference Layer

Purpose	Sets depth cell range for water-track reference layer averaging.
Format	WLsss,eee
Range	sss = Starting depth cell (0-128; 0 disables this feature)
	eee = Ending depth cell (1-128)
Default	WL1,5

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description You can use the WL-command to lower the effects of transducer motion on present measurements for multiple-ping ensembles (WP > 1). The DVL does this by averaging the velocities of a column of water and subtracting that average from each of the depth cell velocities. The DVL accumulates the resulting average velocity and depth cell velocities. At the end on an ensemble, the DVL adds the average reference velocity back to the normalized depth cell velocities. This results in quieter data for depth cells in which there were few good samples.

WN – Number of Depth Cells

Purpose	Sets the number of depth cells over which the Navigator collects data.
Format	WN*nnn*
Range	*nnn* = 001 to 255 depth cells
Default	WN030

Recommended Setting. Set using *WinSC*, *VmDas*, or *WinRiver*.

Description	The range of the Navigator is set by the number of depth cells (WN) times the size of each depth cell (WS).

WP – Pings per Ensemble

Purpose	Sets the number of pings to average in each data ensemble.
Format	WP*nnnnn*
Range	*nnnnn* = 0 to 16384 pings
Default	WP0

Recommended Setting. Set using *WinSC*, *VmDas*, or *WinRiver*.

Description	WP sets the number of pings to average in each ensemble before sending/recording the data.

NOTES.

1. If WP = zero the Navigator does not collect water-profile data.
2. The Navigator automatically extends the ensemble interval (TE) if WP x TP > TE.

WQ - Sample Ambient Sound

Purpose	Samples ambient sound.
Format	WQn
Range	n = 0 (Off), 1 (On)
Default	WQ0

Recommended Setting. The default setting for this command is recommended for most applications.

Description When WQ is set to 1, the DVL samples RSSI before the water ping. WQ uses an 8-meter blank and 8-meter depth cell before sending water-profiling pings.

WS – Depth Cell Size

Purpose Selects the volume of water for one measurement cell.

Format WS*nnnn*

Range See below

Default See below

	75kHz	150kHz	300kHz	600kHz	1200kHz	2400kHz
Range	80 to 3200 cm	40 to 3200 cm	20 to 1600 cm	10 to 800 cm	5 to 400 cm	5 to 200 cm
Default	WS1600	WS0800	WS0400	WS0200	WS0100	WS0050

Recommended Setting. Set using *WinSC*, *VmDas*, or *WinRiver*.

Description The Navigator collects data over a variable number of depth cells. WS sets the size of each cell in vertical centimeters.

NOTE. If you set WS to a value less than its minimum value or greater than its maximum value, the Navigator will accept the entry, but uses the appropriate minimum or maximum value. For example, if you enter WS0001 for a 75kHz system, the Navigator uses a value of 80 cm for WS. Similarly, if you enter WS8000, the Navigator uses a value of 6400 cm for WS.

WT - Transmit Length

Purpose Selects a transmit length different from the depth cell length (cell sampling interval) as set by the WS-command.

Format WT*nnnn*

Range *nnnn* = 0 to 3200 cm

Default WT0000

Recommended Setting. The default setting for this command is recommended for most applications.

Description When WT is set to zero, the transmit signal is set to the depth cell size (WS-command). This is the default setting. Setting WT allows selection of a transmit length different then the area depth cell size (sampling length).

WV – Ambiguity Velocity

Purpose	Sets the radial ambiguity velocity.
Format	WV*nnn*
Range	*nnn* = 002 to 700 cm/s
Default	WV175

> **Recommended Setting.** It is strongly recommended that the WV command be left at its' default value of 175.

Description

Set WV as low as possible to attain maximum performance, but not too low or ambiguity errors will occur. Rule of thumb: Set WV to the maximum relative horizontal velocity between water-current speed and Navigator speed.

The WV command (ambiguity velocity setting) sets the maximum velocity that can be measured along the beam when operating in water mode 1 (WM1). WV is used to improve the single-ping standard deviation. The lower the value of WV, the lower the single-ping standard deviation.

The *WB*-command influences profiling range. If you narrow the bandwidth of the system, the profiling range is increased. An increase in range of approximately 10% is obtained each time the bandwidth is reduced by one-half.

You are required to set the WV command based on the maximum apparent velocity (DVL motion plus water speed). The following formula is used to determine the setting of the WV command: WV = (Max. Apparent Vel. cm/s) * sin(beam angle) * 1.2

> **NOTE.** Note that the minimum setting of the WV command is WV002 and the maximum setting due to internal processing limitations is limited based on the setting of the bandwidth command, WB.
>
> If you set the WB command to WB1 and select a value larger than WV330, the firmware will indicate that it is using the value you selected, but will actually use a value of WV330.
>
> When the WB command is set to WB0, the max value is WV700.
>
> In either case, while you can set a value as low as 2 cm/s, this will likely cause ambiguity errors.

Valid data can be collected if the following WV values are not exceeded. The maximum WV values depend on the WB setting as listed below. Be aware that the firmware will accept larger values for the WV command; however, WV values that exceed the following values will result in collecting data with ambiguity resolving errors or completely erroneous values.

Table 42: WV-command Maximum Setting (20 Degree)

WB Command	Bandwidth	WV (max cm/s)	Apparent Velocity (max cm/s)
0	25%	700	1,705
1	12%	330	804

Example — If the maximum expected Navigator velocity (vessel velocity) is 250 cm/s (≈5 kt) and the maximum expected horizontal water velocity is 100 cm/s, set WV to 350 cm/s.

CAUTION. If a NarrowBand width and a high ambiguity velocity (higher than 330) are selected, the instrument will output garbage data at high currents (for example, in a Vessel Mount deployment).

11.11.3 High Resolution Water Profiling

This section defines the optional High Resolution Water-Profiling commands used by the DVL.

NOTE. High Resolution Water Profiling is a feature upgrade for Navigator DVLs (see “Feature Upgrades,” page 121).

WK – Depth Cell Size Override (Mode 11/12 Only)

Purpose — Determines the depth cell size for Mode 11 and Mode 12 profiling.

Format — WK*x*

Range — *x* = 0 to frequency dependent maximum for WS command.

Default — WK0

Recommended Setting. The default setting for this command is recommended for most applications.

Description — The WK command allows a depth cell size that is smaller than the minimum allowed by the WS command. If WK is set to other than zero it overrides the depth cell size selected by the WS command. If WK is set to zero the WS command takes precedence.

NOTE. This command is only available if the High Rate Ping feature or the High Resolution Water Modes feature is enabled. This command has no effect unless the WM command is set to either 11 or 12.

WM - Profiling Mode

Purpose	Selects the application-dependent profiling mode used by the DVL.
Format	WMn
Range	n = 1, 5, 8, 11, and 12 (see description)
Default	WM1

Recommended Setting. The default setting for this command is recommended for most applications.

Description The WM-command lets you select an application-dependent profiling mode. The chosen mode selects the types of pings transmitted. The ping type depends on how much the water-current is changing from ping-to-ping and from cell-to-cell.

Table 43: Water Modes

Mode	Description
WM1	Dynamic Sea State
WM5	Very Low Standard Deviation, used in low flow
WM8	Very Shallow Water, used in low flow
WM11	High Resolution Mode
WM12	High Rate Ping

NOTE. Water Mode 11 is included in the High Resolution Water Profiling feature upgrade. Water Mode 12 is a separate feature upgrade for Navigator DVLs (see the "Feature Upgrades," page 121).

CAUTION. Water Modes 5, 8, 11, and 12 were designed for 600 and 1200kHz DVLs only. Using these modes on other frequency DVLs may be possible, but only at the user's risk.

NOTES. For general information on the Water Modes, see the *Principles of Operation: A Practical Primer* and the *WinRiver* User's Guide. For detailed information on each Water Mode, see the following Field Service Application Notes (FSAs).

FSA-004 – WM1

FSA-005 – WM5 and WM8

FSA-013 – WM11

FSA-014 – WM12

FSAs are available for download at www.rdinstruments.com, Customer Support page.

WO – Mode 12 Parameters

Purpose	Controls the behavior of Mode 12 water profiling.
Format	WO*x,y*
Range	*x* = 1 to 100 sub-pings
	y = 0 to 999 hundredths of seconds
Default	WO1, 4

> **Recommended Setting.** Special applications only.

Description: The WO command governs the behavior of Mode 12 water profiling. In Mode 12, a number of sub-pings are transmitted very rapidly and their results are averaged internally to form a single Mode 12 ping. The number of sub-pings is determined by the *x* parameter. The *y* parameter sets the time between sub-pings in hundredths of a second.

> **NOTE.** This command is only available when the High Rate Ping feature is enabled. This command has no effect unless the WM command is set to WM12.

WZ - Mode 5 Ambiguity Velocity

Purpose	Sets the minimum radial ambiguity for profiling Mode 5 (WM5) and Mode 8 (WM8) Ambiguity Velocity.
Format	WZ*nnn*
Range	*nnn* = 3 to 80 cm/s
Default	WZ05

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description: Allows for very high resolution (small bins) with very low standard deviation.

The maximum value at which WM5 will work is related to bottom track depth. The larger the WZ value, the shallower the water has to be.

12 Introduction to Output Data Format

This section shows the output data format of the Navigator (including the Monitor/Sentinel, Navigator, Rio Grande H-DVLs, and Long Ranger). Navigator output data can be in either hexadecimal-ASCII or binary format. You can select this option through the CF-command (see the "CF - Flow Control," page 154). We explain the output data formats in enough detail to let you create your own data processing or analysis programs (see "How to Decode a DVL Ensemble," page 265).

12.1 Hexadecimal-ASCII Output Data

Use the hexadecimal-ASCII (Hex ASCII) format (CFxx0xx) when you are viewing raw Navigator data on a computer/dumb terminal. This format uses the standard ASCII codes for 0 through F to represent numeric values as hexadecimal digits. Other standard ASCII characters (text) and control commands (carriage return, line feed, end of file, etc.) are interpreted normally. In the Hex ASCII mode, the Navigator sends data in one line of ASCII characters. There are no carriage returns and/or line feed sequences (CR/LF) sent from the DVL. The CRT provides a CR/LF after 60 characters.

NOTE. Hex ASCII PD0 data is not supported by TRDI's software.

12.2 Binary Output Data Format

Use the binary format (CFxx1xx) when recording/processing Navigator data on an external device. The binary format uses less storage space and has a faster transmission time than the Hex ASCII format. A dumb terminal is of little use in binary format because the terminal interprets some of the data as control characters.

NOTE. All of TRDI's software supports binary PD0 formatted data only.

13 PD0 Output Data Format

The following description is for the standard PD0 Navigator output data format. Figure 43, page 216 through Figure 50, page 241 shows the ASCII and binary data formats for the Navigator PD0 mode. Table 44, page 217 through Table 53, page 241 defines each field in the output data structure.

After completing a data collection cycle, the Navigator immediately sends a data ensemble. The following pages show the types and sequence of data that you may include in the Navigator output data ensemble and the number of bytes required for each data type. The Navigator sends all the data for a given type for all depth cells and all beams before the next data type begins.

The Navigator by default is set to collect bottom track data. The data, preceded by ID code 7F7F, contains header data (explained in Table 44, page 217). The fixed and variable leader data is preceded by ID codes 0000 and 8000, (explained in Table 45, page 220 and Table 46, page 226). The Navigator always collects Header and Leader. Bottom Track data is preceded by ID codes 0600 (explained in Table 51, page 239).

If water profiling is enabled, the remaining lines include velocity (ID Code: 0001), correlation magnitude (0002), echo intensity (0003), and percent good (0004). The final field is a data-validity checksum.

ALWAYS OUTPUT	**HEADER** (6 BYTES + [2 x No. OF DATA TYPES])
	FIXED LEADER DATA (59 BYTES)
	VARIABLE LEADER DATA (65 BYTES)
WATER PROFILING DATA WD-command WP-command	**VELOCITY** (2 BYTES + 8 BYTES PER DEPTH CELL)
	CORRELATION MAGNITUDE (2 BYTES + 4 BYTES PER DEPTH CELL)
	ECHO INTENSITY (2 BYTES + 4 BYTES PER DEPTH CELL)
	PERCENT GOOD (2 BYTES + 4 BYTES PER DEPTH CELL)
BP-command	**BOTTOM TRACK DATA** (85 BYTES)
ALWAYS OUTPUT	**RESERVED** (2 BYTES)
	CHECKSUM (2 BYTES)

Figure 42. PD0 Standard Output Data Buffer Format

NOTE. Water Profiling is a feature upgrade for Navigator DVLs (see "Feature Upgrades," page 121). Contact TRDI for information on how to install Water Profiling capability in your Navigator. Some commands are listed in the following tables, even though they are not adjustable without the water profiling feature.

Some data outputs are in bytes per depth cell. For example, if the WN-command (number of depth cells) = 30 (default), WD command = WD 111 100 000 (default), WP command > 0, BP command > 0, the required data buffer storage space is 841 bytes per ensemble.

There are seven data types output for this example: Fixed Leader, Variable Leader, Velocity, Correlation Magnitude, Echo Intensity, Percent Good, and Bottom Track.

```
 20   BYTES OF HEADER DATA (6 + [2 x 7 Data Types])
 59   BYTES OF FIXED LEADER DATA (FIXED)
 65   BYTES OF VARIABLE LEADER DATA (FIXED)
242   BYTES OF VELOCITY DATA (2 + 8 x 30)
122   BYTES OF CORRELATION MAGNITUDE DATA (2 + 4 x 30)
122   BYTES OF ECHO INTENSITY (2 + 4 x 30)
122   BYTES OF PERCENT-GOOD DATA (2 + 4 x 30)
 85   BYTES OF BOTTOM TRACK DATA (FIXED)
  2   BYTES OF RESERVED FOR TRDI USE (FIXED)
  2   BYTES OF CHECKSUM DATA (FIXED)
-----------------------------------------------------
841   BYTES OF DATA PER ENSEMBLE
```

NOTE. *WinRiver* and *VmDas* may add additional bytes.

For example, WinRiver does not add any bytes to the Bottom Track data, but does insert data in place of other bytes. The Navigation NMEA strings (up to 275 bytes) are stored in the *r.000 raw data between the Bottom Track data and the Reserved/Checksum data. WinRiver output data format is described in the WinRiver User's Guide.

VmDas adds 78 bytes of Navigation data between the Bottom Track data and the Reserved/Checksum data. The ENR file (raw data from the DVL) does not have these bytes, only the ENS, ENX, STA and LTA files. VmDas output data format is described in the VmDas User's Guide.

13.1 Header Data Format

BIT POSITIONS

BYTE	7	6	5	4	3	2	1	0	
1	HEADER ID (7Fh)								
2	DATA SOURCE ID (7Fh)								
3	NUMBER OF BYTES IN ENSEMBLE								LSB
4									MSB
5	SPARE								
6	NUMBER OF DATA TYPES								
7	OFFSET FOR DATA TYPE #1								LSB
8									MSB
9	OFFSET FOR DATA TYPE #2								LSB
10									MSB
11	OFFSET FOR DATA TYPE #3								LSB
12									MSB
↓	(SEQUENCE CONTINUES FOR UP TO N DATA TYPES)								↓
2N+5	OFFSET FOR DATA TYPE #N								LSB
2N+6									MSB

See Table 44, page 217 for a description of the fields.

Figure 43. Binary Header Data Format

NOTE. This data is always output in this format.

Header information is the first item sent by the DVL to the output buffer. The Navigator always sends the Least Significant Byte (LSB) first.

Table 44: Header Data Format

Hex Digit	Binary Byte	Field	Description
1,2	1	HDR ID / Header ID	Stores the header identification byte (7Fh).
3,4	2	HDR ID / Data Source ID	Stores the data source identification byte (7Fh for the Navigator).
5-8	3,4	Bytes / Number of bytes in ensemble	This field contains the number of bytes from the start of the current ensemble up to, but not including, the 2-byte checksum (Figure 50, page 241).
9,10	5	Spare	Undefined.
11,12	6	No. DT / Number of Data Types	This field contains the number of data types selected for collection. By default, fixed/variable leader, velocity, correlation magnitude, echo intensity, and percent good are selected for collection. This field will therefore have a value of six (4 data types + 2 for the Fixed/Variable Leader data).
13-16	7,8	Address Offset for Data Type #1 / Offset for Data Type #1	This field contains the internal memory address offset where the Navigator will store information for data type #1 (with this firmware, always the Fixed Leader). Adding “1” to this offset number gives the absolute Binary Byte number in the ensemble where Data Type #1 begins (the first byte of the ensemble is Binary Byte #1).
17-20	9,10	Address Offset for Data Type #2 / Offset for Data Type #2	This field contains the internal memory address offset where the Navigator will store information for data type #2 (with this firmware, always the Variable Leader). Adding “1” to this offset number gives the absolute Binary Byte number in the ensemble where Data Type #2 begins (the first byte of the ensemble is Binary Byte #1).
21-24 thru 2n+13 to 2n+16	11,12 thru 2n+5, 2n+6	Address Offsets for Data Types #3-n / Offset for Data Type #3 through #n	These fields contain internal memory address offset where the Navigator will store information for data type #3 through data type #n. Adding “1” to this offset number gives the absolute Binary Byte number in the ensemble where Data Types #3-n begin (first byte of ensemble is Binary Byte) #1).

13.2 Fixed Leader Data Format

BYTE	BIT POSITIONS 7 6 5 4 3 2 1 0	
1	FIXED LEADER ID	LSB 00h
2		MSB 00h
3	CPU F/W VER.	
4	CPU F/W REV.	
5	SYSTEM CONFIGURATION	LSB
6		MSB
7	REAL/SIM FLAG	
8	LAG LENGTH	
9	NUMBER OF BEAMS	
10	NUMBER OF CELLS {WN}	
11	PINGS PER ENSEMBLE {WP}	LSB
12		MSB
13	DEPTH CELL LENGTH {WS}	LSB
14		MSB
15	BLANK AFTER TRANSMIT {WF}	LSB
16		MSB
17	PROFILING MODE {WM}	
18	LOW CORR THRESH {WC}	
19	NO. CODE REPS	
20	%GD MINIMUM {WG}	
21	ERROR VELOCITY MAXIMUM {WE}	LSB
22		MSB
23	TPP MINUTES	
24	TPP SECONDS	
25	TPP HUNDREDTHS {TP}	
26	COORDINATE TRANSFORM {EX}	
27	HEADING ALIGNMENT {EA}	LSB
28		MSB

Continued Next Page

Continued from Previous Page

29	HEADING BIAS {EB}	LSB
30		MSB
31	SENSOR SOURCE {EZ}	
32	SENSORS AVAILABLE	
33	BIN 1 DISTANCE	
34		
35	XMIT PULSE LENGTH BASED ON {WT}	LSB
36		MSB
37	(starting cell) WP REF LAYER AVERAGE {WL} (ending cell)	LSB
38		MSB
39	FALSE TARGET THRESH {WA}	
40	SPARE	
41	TRANSMIT LAG DISTANCE	LSB
42		MSB
43	CPU BOARD SERIAL NUMBER	LSB
↓		↓
50		MSB
51	SYSTEM BANDWIDTH {WB}	LSB
52		MSB
53	SPARE	
54	BASE FREQUENCY INDEX	
55	SPARE	
↓		↓
59		

See Table 45, page 220 for a description of the fields

Figure 44. Fixed Leader Data Format

NOTE. This data is always output in this format.

Fixed Leader data refers to the non-dynamic Navigator data that only changes when you change certain commands. Fixed Leader data also contain hardware information. The Navigator always sends Fixed Leader data as output data (LSBs first).

Table 45: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	FID / Fixed Leader ID	Stores the Fixed Leader identification word (00 00h).
5,6	3	fv / CPU F/W Ver.	Contains the version number of the CPU firmware.
7,8	4	fr / CPU F/W Rev.	Contains the revision number of the CPU firmware.

9-12	5,6	Sys Cfg / System Configuration	This field defines the Navigator hardware configuration. Convert this field (2 bytes, LSB first) to binary and interpret as follows.
			`LSB`
			`BITS  7 6 5 4 3 2 1 0`
			`      - - - - - 0 0 0   75-kHz SYSTEM`
			`      - - - - - 0 0 1   150-kHz SYSTEM`
			`      - - - - - 0 1 0   300-kHz SYSTEM`
			`      - - - - - 0 1 1   600-kHz SYSTEM`
			`      - - - - - 1 0 0  1200-kHz SYSTEM`
			`      - - - - - 1 0 1  2400-kHz SYSTEM`
			`      - - - - 0 - - -  CONCAVE BEAM PAT.`
			`      - - - - 1 - - -  CONVEX BEAM PAT.`
			`      - - 0 0 - - - -  SENSOR CONFIG #1`
			`      - - 0 1 - - - -  SENSOR CONFIG #2`
			`      - - 1 0 - - - -  SENSOR CONFIG #3`
			`      - 0 - - - - - -  XDCR HD NOT ATT.`
			`      - 1 - - - - - -  XDCR HD ATTACHED`
			`      0 - - - - - - -  DOWN FACING BEAM`
			`      1 - - - - - - -  UP-FACING BEAM`
			
			`MSB`
			`BITS  7 6 5 4 3 2 1 0`
			`      - - - - - - 0 0  15E BEAM ANGLE`
			`      - - - - - - 0 1  20E BEAM ANGLE`
			`      - - - - - - 1 0  30E BEAM ANGLE`
			`      - - - - - - 1 1  OTHER BEAM ANGLE`
			`      0 1 0 0 - - - -  4-BEAM JANUS CONFIG`
			`      0 1 0 1 - - - -  5-BM JANUS CFIG DEMOD)`
			`      1 1 1 1 - - - -  5-BM JANUS CFIG.(2`
			`DEMD)`
			Example: Hex 5249 (i.e., hex 49 followed by hex 52) identifies a 150-kHz system, convex beam pattern, down-facing, 30E beam angle, 5 beams (3 demods).

13,14	7	PD / Real/Sim Flag	This field is set by default as real data (0).

Continued next page

Table 45: Fixed Leader Data Format (continued)

Hex Digit	Binary Byte	Field	Description
15,16	8	Lag Length	Lag Length. The lag is the time period between sound pulses. This is varied, and therefore of interest in, at a minimum, for the WM5, WM8 and WM11 and BM7 commands.
17,18	9	#Bm / Number of Beams	Contains the number of beams used to calculate velocity data (not physical beams). The Navigator needs only three beams to calculate water-current velocities. The fourth beam provides an error velocity that determines data validity. If only three beams are available, the Navigator does not make this validity check. Table 50, page 235 (Percent-Good Data Format) has more information.
19,20	10	WN / Number of Cells	Contains the number of depth cells over which the Navigator collects data (WN-command). Scaling: LSD = 1 depth cell; Range = 1 to 128 depth cells
21-24	11,12	WP / Pings Per Ensemble	Contains the number of pings averaged together during a data ensemble (WP-command). If WP = 0, the Navigator does not collect the WD water-profile data. Note: The Navigator automatically extends the ensemble interval (TE) if the product of WP and time per ping (TP) is greater than TE (i.e., if WP x TP > TE). Scaling: LSD = 1 ping; Range = 0 to 16,384 pings
25-28	13,14	WS / Depth Cell Length	Contains the length of one depth cell (WS-command). Scaling: LSD = 1 centimeter; Range = 1 to 6400 cm (210 feet)
29-32	15,16	WF / Blank after Transmit	Contains the blanking distance used by the Navigator to allow the transmit circuits time to recover before the receive cycle begins (WF-command). Scaling: LSD = 1 centimeter; Range = 0 to 9999 cm (328 feet)
33,34	17	Signal Processing Mode	Contains the Signal Processing Mode. This field will always be set to 1.
35,36	18	WC / Low Corr Thresh	Contains the minimum threshold of correlation that water-profile data can have to be considered good data (WC-command). Scaling: LSD = 1 count; Range = 0 to 255 counts
37,38	19	cr# / No. code reps	Contains the number of code repetitions in the transmit pulse. Scaling: LSD = 1 count; Range = 0 to 255 counts
39,40	20	WG / %Gd Minimum	Contains the minimum percentage of water-profiling pings in an ensemble that must be considered good to output velocity data. Scaling: LSD = 1 percent; Range = 1 to 100 percent
41-44	21,22	WE / Error Velocity Threshold	This field, initially set by the WE-command, contains the actual threshold value used to flag water-current data as good or bad. If the error velocity value exceeds this threshold, the Navigator flags all four beams of the affected bin as bad. Scaling: LSD = 1 mm/s; Range = 0 to 5000 mm/s
45,46 47,48 49,50	23 24 25	Minutes Seconds Hundredths	These fields, set by the TP-command, contain the amount of time between ping groups in the ensemble. NOTE: The Navigator automatically extends the ensemble interval (set by TE) if (WP x TP > TE).

Table 45: Fixed Leader Data Format (continued)

Hex Digit	Binary Byte	Field	Description

51,52	26	EX / Coord Transform	Contains the coordinate transformation processing parameters (EX-command). These firmware switches indicate how the Navigator collected data.
			`xxx00xxx = NO TRANSFORMATION (BEAM COORDINATES)`
			`xxx01xxx = INSTRUMENT COORDINATES`
			`xxx10xxx = SHIP COORDINATES`
			`xxx11xxx = EARTH COORDINATES`
			`xxxxx1xx = TILTS (PITCH AND ROLL) USED IN SHIP OR EARTH TRANSFORMATION`
			`xxxxxx1x = 3-BEAM SOLUTION USED IF ONE BEAM IS BELOW THE CORRELATION THRESHOLD SET BY THE WC-COMMAND`
			`xxxxxxx1 = BIN MAPPING USED`

53-56	27,28	EA / Heading Alignment	Contains a correction factor for physical heading misalignment (EA-command). Scaling: LSD = 0.01 degree; Range = -179.99 to 180.00 degrees
57-60	29,30	EB / Heading Bias	Contains a correction factor for electrical/magnetic heading bias (EB-command). Scaling: LSD = 0.01 degree; Range = -179.99 to 180.00 degrees

61,62	31	EZ / Sensor Source	Contains the selected source of environmental sensor data (EZ-command). These firmware switches indicate the following.
			`FIELD        DESCRIPTION`
			`x1xxxxxx = CALCULATES EC (SPEED OF SOUND) FROM ED, ES, AND ET`
			`xx1xxxxx = USES ED FROM DEPTH SENSOR`
			`xxx1xxxx = USES EH FROM TRANSDUCER HEADING SENSOR`
			`xxxx1xxx = USES EP FROM TRANSDUCER PITCH SENSOR`
			`xxxxx1xx = USES ER FROM TRANSDUCER ROLL SENSOR`
			`xxxxxx1x = USES ES (SALINITY) FROM CONDUCTIVITY SENSOR`
			`xxxxxxx1 = USES ET FROM TRANSDUCER TEMPERATURE SENSOR`
			NOTE: If the field = 0, or if the sensor is not available, the Navigator uses the manual command setting. If the field = 1, the Navigator uses the reading from the internal sensor or an external synchro sensor (only applicable to heading, roll, and pitch). Although you can enter a “2” in the EZ-command string, the Navigator only displays a 0 (manual) or 1 (int/ext sensor).

63,64	32	Sensor Avail	This field reflects which sensors are available. The bit pattern is the same as listed for the EZ-command (above).
65-68	33,34	dis1 / Bin 1 distance	This field contains the distance to the middle of the first depth cell (bin). This distance is a function of depth cell length (WS), the profiling mode (WM), the blank after transmit distance (WF), and speed of sound. Scaling: LSD = 1 centimeter; Range = 0 to 65535 cm (2150 feet)

Table 45: Fixed Leader Data Format (continued)

Hex Digit	Binary Byte	Field	Description
69-72	35,36	WT Xmit pulse length	This field, set by the WT-command, contains the length of the transmit pulse. When the Navigator receives a <BREAK> signal, it sets the transmit pulse length as close as possible to the depth cell length (WS-command). This means the Navigator uses a WT command of zero. However, the WT field contains the actual length of the transmit pulse used. Scaling: LSD = 1 centimeter; Range = 0 to 65535 cm (2150 feet)
73,74 75,76	37,38	WL / WP Ref Lyr Avg (Starting cell, Ending cell)	Contains the starting depth cell (LSB, byte 37) and the ending depth cell (MSB, byte 38) used for water reference layer averaging (WL-command). Scaling: LSD = 1 depth cell; Range = 1 to 128 depth cells
77,78	39	WA / False Target Threshold	Contains the threshold value used to reject data received from a false target, usually fish (WA-command). Scaling: LSD = 1 count; Range = 0 to 255 counts (255 disables)
79,80	40	Spare	Contains the CX-command setting. Range = 0 to 5
81-84	41,42	LagD / Transmit lag distance	This field, determined mainly by the setting of the WM-command, contains the distance between pulse repetitions. Scaling: LSD = 1 centimeter; Range = 0 to 65535 centimeters
85-100	43-50	CPU Board Serial Number	Contains the serial number of the CPU board.
101-105	51-52	WB / System Bandwidth	Contains the WB-command setting. Range = 0 to 1
106-107	53	Spare	Spare
108-109	54	Base Freq Index	Base frequency index.
110-121	55-59	Spare	Spare

13.3 Variable Leader Data Format

BIT POSITIONS

BYTE	7	6	5	4	3	2	1	0	
1	VARIABLE LEADER ID								80h
2									00h
3	ENSEMBLE NUMBER								LSB
4									MSB
5	RTC YEAR {TS}								
6	RTC MONTH {TS}								
7	RTC DAY {TS}								
8	RTC HOUR {TS}								
9	RTC MINUTE {TS}								
10	RTC SECOND {TS}								
11	RTC HUNDREDTHS {TS}								
12	ENSEMBLE # MSB								
13	BIT RESULT								LSB
14									MSB
15	SPEED OF SOUND {EC}								LSB
16									MSB
17	DEPTH OF TRANSDUCER {ED}								LSB
18									MSB
19	HEADING {EH}								LSB
20									MSB
21	PITCH (TILT 1) {EP}								LSB
22									MSB
23	ROLL (TILT 2) {ER}								LSB
24									MSB
25	SALINITY {ES}								LSB
26									MSB
27	TEMPERATURE {ET}								LSB
28									MSB
29	MPT MINUTES								
30	MPT SECONDS								
31	MPT HUNDREDTHS								
32	HDG STD DEV								
33	PITCH STD DEV								
34	ROLL STD DEV								

Continued Next Page

Continued from Previous Page

35	ADC CHANNEL 0	
36	ADC CHANNEL 1	
37	ADC CHANNEL 2	
38	ADC CHANNEL 3	
39	ADC CHANNEL 4	
40	ADC CHANNEL 5	
41	ADC CHANNEL 6	
42	ADC CHANNEL 7	
43	ERROR STATUS WORD (ESW) {CY?}	LSB
44		
45		
46		MSB
47	SPARE	
48		
49	PRESSURE	LSB
50		
51		
52		MSB
53	PRESSURE SENSOR VARIANCE	LSB
54		
55		
56		MSB
57	SPARE	
58	RTC CENTURY	
59	RTC YEAR	
60	RTC MONTH	
61	RTC DAY	
62	RTC HOUR	
63	RTC MINUTE	
64	RTC SECOND	
65	RTC HUNDREDTH	

See Table 46, page 226 for a description of the fields.

Figure 45. Variable Leader Data Format

NOTE. This data is always output in this format.

Variable Leader data refers to the dynamic Navigator data (from clocks/sensors) that change with each ping. The Navigator always sends Variable Leader data as output data (LSBs first).

Table 46: Variable Leader Data Format

<table>
<tr><th>Hex Digit</th><th>Binary Byte</th><th>Field</th><th>Description</th></tr>
<tr><td>1-4</td><td>1,2</td><td>VID / Variable Leader ID</td><td>Stores the Variable Leader identification word (80 00h).</td></tr>
<tr><td>5-8</td><td>3,4</td><td>Ens / Ensemble Number</td><td>This field contains the sequential number of the ensemble to which the data in the output buffer apply.

Scaling: LSD = 1 ensemble; Range = 1 to 65,535 ensembles

NOTE: The first ensemble collected is #1. At “rollover,” we have the following sequence:
1 = ENSEMBLE NUMBER 1
↓
65535 = ENSEMBLE NUMBER 65,535 | ENSEMBLE
0 = ENSEMBLE NUMBER 65,536 | #MSB FIELD
1 = ENSEMBLE NUMBER 65,537 | (BYTE 12)
INCR.</td></tr>
<tr><td>9,10</td><td>5</td><td>RTC Year</td><td>These fields contain the time from the Navigator’s real-time clock (RTC) that the current data ensemble began. The TS-command (Set Real-Time Clock) initially sets the clock. The Navigator <u>does</u> account for leap years.</td></tr>
<tr><td>11,12</td><td>6</td><td>RTC Month</td><td></td></tr>
<tr><td>13,14</td><td>7</td><td>RTC Day</td><td></td></tr>
<tr><td>15,16</td><td>8</td><td>RTC Hour</td><td></td></tr>
<tr><td>17,18</td><td>9</td><td>RTC Minute</td><td></td></tr>
<tr><td>19,22</td><td>10</td><td>RTC Second</td><td></td></tr>
<tr><td>21,22</td><td>11</td><td>RTC Hundredths</td><td></td></tr>
<tr><td>23-24</td><td>12</td><td>Ensemble # MSB</td><td>This field increments each time the Ensemble Number field (bytes 3,4) “rolls over.” This allows ensembles up to 16,777,215. See Ensemble Number field above.</td></tr>
<tr><td>25-28</td><td>13,14</td><td>BIT / BIT Result</td><td>This field contains the results of the Navigator’s Built-in Test function. A zero code indicates a successful BIT result.
BYTE 13 BYTE 14 (BYTE 14 RESERVED FOR FUTURE USE)
1xxxxxxx xxxxxxxx = RESERVED
x1xxxxxx xxxxxxxx = RESERVED
xx1xxxxx xxxxxxxx = RESERVED
xxx1xxxx xxxxxxxx = DEMOD 1 ERROR
xxxx1xxx xxxxxxxx = DEMOD 0 ERROR
xxxxx1xx xxxxxxxx = RESERVED
xxxxxx1x xxxxxxxx = TIMING CARD ERROR
xxxxxxx1 xxxxxxxx = RESERVED</td></tr>
<tr><td>29-32</td><td>15,16</td><td>EC / Speed of Sound</td><td>Contains either manual or calculated speed of sound information (EC-command).

Scaling: LSD = 1 meter per second; Range = 1400 to 1600 m/s</td></tr>
</table>

Continued next page

Table 46: Variable Leader Data Format (continued)

Hex Digit	Binary Byte	Field	Description
33-36	17,18	ED / Depth of Transducer	Contains the depth of the transducer below the water surface (ED-command). This value may be a manual setting or a reading from a depth sensor. Scaling: LSD = 1 decimeter; Range = 1 to 9999 decimeters
37-40	19,20	EH / Heading	Contains the Navigator heading angle (EH-command). This value may be a manual setting or a reading from a heading sensor. Scaling: LSD = 0.01 degree; Range = 000.00 to 359.99 degrees
41-44	21,22	EP / Pitch (Tilt 1)	Contains the Navigator pitch angle (EP-command). This value may be a manual setting or a reading from a tilt sensor. Positive values mean that Beam #3 is spatially higher than Beam #4. Scaling: LSD = 0.01 degree; Range = -20.00 to +20.00 degrees
45-48	23,24	ER / Roll (Tilt 2)	Contains the Navigator roll angle (ER-command). This value may be a manual setting or a reading from a tilt sensor. For up-facing Navigators, positive values mean that Beam #2 is spatially higher than Beam #1. For down-facing Navigators, positive values mean that Beam #1 is spatially higher than Beam #2. Scaling: LSD = 0.01 degree; Range = -20.00 to +20.00 degrees
49-52	25,26	ES / Salinity	Contains the salinity value of the water at the transducer head (ES-command). This value may be a manual setting or a reading from a conductivity sensor. Scaling: LSD = 1 part per thousand; Range = 0 to 40 ppt
53-56	27,28	ET / Temperature	Contains the temperature of the water at the transducer head (ET-command). This value may be a manual setting or a reading from a temperature sensor. Scaling: LSD = 0.01 degree; Range = -5.00 to +40.00 degrees
57,58	29	MPT minutes	This field contains the Minimum Pre-Ping Wait Time between ping groups in the ensemble.
59,60	30	MPT seconds	
61,62	31	MPT hundredths	
63,64	32	H/Hdg Std Dev	These fields contain the standard deviation (accuracy) of the heading and tilt angles from the gyrocompass/pendulums. Scaling (Heading): LSD = 1°; Range = 0 to 180° Scaling (Tilts): LSD = 0.1°; Range = 0.0 to 20.0°
65,66	33	P/Pitch Std Dev	
67,68	34	R/Roll Std Dev	

Table 46: Variable Leader Data Format (continued)

Hex Digit	Binary Byte	Field	Description

69-70	35	ADC Channel 0	These fields contain the outputs of the Analog-to-Digital Converter (ADC) located on the DSP board. The ADC sequentially samples one of the eight channels per ping group (the number of ping groups per ensemble is the maximum of the WP). These fields are zeroed at the beginning of the deployment and updated each ensemble at the rate of one channel per ping group. For example, if the ping group size is 5, then:
			`END OF ENSEMBLE No.     CHANNELS UPDATED`
			`       Start            All channels = 0`
			`         1              0, 1, 2, 3, 4`
			`         2              5, 6, 7, 0, 1`
			`         3              2, 3, 4, 5, 6`
			`         4              7, 0, 8, 2, 3`
			`         ↓                    ↓`
			Here is the description for each channel:
			`CHANNEL  DESCRIPTION`
			`0        XMIT CURRENT`
			`1        XMIT VOLTAGE`
			`2        AMBIENT TEMP`
			`3        PRESSURE (+)`
			`4        PRESSURE (-)`
			`5        ATTITUDE TEMP`
			`6        ATTITUDE`
			`7        CONTAMINATION SENSOR`
			Note that the ADC values may be "noisy" from sample-to-sample, but are useful for detecting long-term trends.

71-72	36	ADC Channel 1	
73-74	37	ADC Channel 2	
75-76	38	ADC Channel 3	
77-78	39	ADC Channel 4	
79-80	40	ADC Channel 5	
81-82	41	ADC Channel 6	
83-84	42	ADC Channel 7	

85-86	43	Error Status Word	Contains the long word containing the bit flags for the CY? Command. The ESW is cleared (set to zero) between each ensemble.
			Note that each number above represents one bit set – they may occur in combinations. For example, if the long word value is 0000C000 (hexadecimal), then it indicates that <u>both</u> a cold wake-up (0004000) and an unknown wake-up (00008000) occurred.
			`Low 16 BITS`
			`LSB`
			`BITS 07 06 05 04 03 02 01 00`
			`     x  x  x  x  x  x  x  1  Bus Error exception`
			`     x  x  x  x  x  x  1  x  Address Error exception`
			`     x  x  x  x  x  1  x  x  Illegal Instruction exception`
			`     x  x  x  x  1  x  x  x  Zero Divide exception`
			`     x  x  x  1  x  x  x  x  Emulator exception`
			`     x  x  1  x  x  x  x  x  Unassigned exception`
			`     x  1  x  x  x  x  x  x  Watchdog restart occurred`
			`     1  x  x  x  x  x  x  x  Battery Saver power`

87-88	44		`Low 16 BITS`
			`MSB`
			`BITS 15 14 13 12 11 10 09 08`
			`     x  x  x  x  x  x  x  1  Pinging`
			`     x  x  x  x  x  x  1  x  Not Used`
			`     x  x  x  x  x  1  x  x  Not Used`
			`     x  x  x  x  1  x  x  x  Not Used`
			`     x  x  x  1  x  x  x  x  Not Used`
			`     x  x  1  x  x  x  x  x  Not Used`
			`     x  1  x  x  x  x  x  x  Cold Wakeup occurred`
			`     1  x  x  x  x  x  x  x  Unknown Wakeup occurred`

89-90	45		`High 16 BITS`
			`LSB`
			`BITS 24 23 22 21 20 19 18 17`
			`     x  x  x  x  x  x  x  1  Clock Read error occurred`
			`     x  x  x  x  x  x  1  x  Unexpected alarm`
			`     x  x  x  x  x  1  x  x  Clock jump forward`
			`     x  x  x  x  1  x  x  x  Clock jump backward`
			`     x  x  x  1  x  x  x  x  Not Used`
			`     x  x  1  x  x  x  x  x  Not Used`
			`     x  1  x  x  x  x  x  x  Not Used`
			`     1  x  x  x  x  x  x  x  Not Used`

Table 46: Variable Leader Data Format (continued)

Hex Digit	Binary Byte	Field	Description

91-92	46		`High 16 BITS`
			`MSB`
			`BITS 32 31 30 29 28 27 26 25`
			`     x  x  x  x  x  x  x  1  Not Used`
			`     x  x  x  x  x  x  1  x  Not Used`
			`     x  x  x  x  x  1  x  x  Not Used`
			`     x  x  x  x  1  x  x  x  Power Fail (Unrecorded)`
			`     x  x  x  1  x  x  x  x  Spurious level 4 intr (DSP)`
			`     x  x  1  x  x  x  x  x  Spurious level 5 intr (UART)`
			`     x  1  x  x  x  x  x  x  Spurious level 6 intr (CLOCK)`
			`     1  x  x  x  x  x  x  x  Level 7 interrupt occurred`

93-96	47-48	Reserved	Reserved for TRDI use.
97-104	49-52	Pressure	Contains the pressure of the water at the transducer head relative to one atmosphere (sea level). Output is in deca-pascals (see "How Does the Navigator Sample Depth and Pressure?," page 56). Scaling: LSD=1 deca-pascal; Range=0 to 4,294,967,295 deca-pascals
105-112	53-56	Pressure variance	Contains the variance (deviation about the mean) of the pressure sensor data. Output is in deca-pascals. Scaling: LSD=1 deca-pascal; Range=0 to 4,294,967,295 deca-pascals
113-114	57	Spare	Spare
115-116	58	RTC Century	These fields contain the time from the Navigator's Y2K compliant real-time clock (RTC) that the current data ensemble began. The TT-command (Set Real-Time Clock) initially sets the clock. The Navigator does account for leap years.
117-118	59	RTC Year	
119-120	60	RTC Month	
121-122	61	RTC Day	
123-124	62	RTC Hour	
125-126	63	RTC Minute	
127-128	64	RTC Seconds	
129-130	65	RTC Hundredths	

13.4 Velocity Data Format

BYTE	BIT POSITIONS: 7/S 6 5 4 3 2 1 0	
1	VELOCITY ID	LSB 00h
2		MSB 01h
3	DEPTH CELL #1, VELOCITY 1	LSB
4		MSB
5	DEPTH CELL #1, VELOCITY 2	LSB
6		MSB
7	DEPTH CELL #1, VELOCITY 3	LSB
8		MSB
9	DEPTH CELL #1, VELOCITY 4	LSB
10		MSB
11	DEPTH CELL #2, VELOCITY 1	LSB
12		MSB
13	DEPTH CELL #2, VELOCITY 2	LSB
14		MSB
15	DEPTH CELL #2, VELOCITY 3	LSB
16		MSB
17	DEPTH CELL #2, VELOCITY 4	LSB
18		MSB
↓	(SEQUENCE CONTINUES FOR UP TO 128 CELLS)	↓
1019	DEPTH CELL #128, VELOCITY 1	LSB
1020		MSB
1021	DEPTH CELL #128, VELOCITY 2	LSB
1022		MSB
1023	DEPTH CELL #128, VELOCITY 3	LSB
1024		MSB
1025	DEPTH CELL #128, VELOCITY 4	LSB
1026		MSB

See Table 47, page 231 for description of fields

Figure 46. Velocity Data Format

NOTE. The number of depth cells is set by the WN-command.

The Navigator packs velocity data for each depth cell of each beam into a two-byte, two's-complement integer [-32768, 32767] with the LSB sent first. The Navigator scales velocity data in millimeters per second (mm/s). A value of –32768 (8000h) indicates bad velocity values.

All velocities are relative based on a stationary instrument. To obtain absolute velocities, algebraically remove the velocity of the instrument. For example,

```
RELATIVE WATER CURRENT VELOCITY:    EAST 650 mm/s
INSTRUMENT VELOCITY            : (-) EAST 600 mm/s
ABSOLUTE WATER VELOCITY        :     EAST  50 mm/s
```

The setting of the EX-command (Coordinate Transformation) determines how the Navigator references the velocity data as shown below.

EX-CMD	COORD SYS	VEL 1	VEL 2	VEL 3	VEL 4
xxx00xxx	BEAM	TO BEAM 1	TO BEAM 2	TO BEAM 3	TO BEAM 4
xxx01xxx	INST	Bm1-Bm2	Bm4-Bm3	TO XDUCER	ERR VEL
xxx10xxx	SHIP	PRT-STBD	AFT-FWD	TO SURFACE	ERR VEL
xxx11xxx	EARTH	TO EAST	TO NORTH	TO SURFACE	ERR VEL

POSITIVE VALUES INDICATE WATER MOVEMENT

Table 47: Velocity Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Velocity ID	Stores the velocity data identification word (00 01h).
5-8	3,4	Depth Cell 1, Velocity 1	Stores velocity data for depth cell #1, velocity 1. See above.
9-12	5,6	Depth Cell 1, Velocity 2	Stores velocity data for depth cell #1, velocity 2. See above.
13-16	7,8	Depth Cell 1, Velocity 3	Stores velocity data for depth cell #1, velocity 3. See above.
17-20	9,10	Depth Cell 1, Velocity 4	Stores velocity data for depth cell #1, velocity 4. See above.
21-2052	11-1026	Cells 2 – 128 (if used)	These fields store the velocity data for depth cells 2 through 128 (depending on the setting of the WN-command). These fields follow the same format as listed above for depth cell 1.

13.5 Correlation Magnitude, Echo Intensity, and Percent-Good Data Format

BIT POSITIONS

BYTE	7/S	6	5	4	3	2	1	0	
1	ID CODE								LSB
2									MSB
3	DEPTH CELL #1, FIELD #1								
4	DEPTH CELL #1, FIELD #2								
5	DEPTH CELL #1, FIELD #3								
6	DEPTH CELL #1, FIELD #4								
7	DEPTH CELL #2, FIELD #1								
8	DEPTH CELL #2, FIELD #2								
9	DEPTH CELL #2, FIELD #3								
10	DEPTH CELL #2, FIELD #4								
↓	(SEQUENCE CONTINUES FOR UP TO 128 BINS)								↓
511	DEPTH CELL #128, FIELD #1								
512	DEPTH CELL #128, FIELD #2								
513	DEPTH CELL #128, FIELD #3								
514	DEPTH CELL #128, FIELD #4								

See Table 48, page 233 through Table 50, page 235 for a description of the fields.

Figure 47. Binary Correlation Magnitude, Echo Intensity, and Percent-Good Data Format

NOTE. The number of depth cells is set by the WN-command.

Correlation magnitude data give the magnitude of the normalized echo autocorrelation at the lag used for estimating the Doppler phase change. The Navigator represents this magnitude by a linear scale between 0 and 255, where 255 is perfect correlation (i.e., a solid target). A value of zero indicates bad correlation values.

Table 48: Correlation Magnitude Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the correlation magnitude data identification word (00 02h).
5,6	3	Depth Cell 1, Field 1	Stores correlation magnitude data for depth cell #1, beam #1. See above.
7,8	4	Depth Cell 1, Field 2	Stores correlation magnitude data for depth cell #1, beam #2. See above.
9,10	5	Depth Cell 1, Field 3	Stores correlation magnitude data for depth cell #1, beam #3. See above.
11,12	6	Depth Cell 1, Field 4	Stores correlation magnitude data for depth cell #1, beam #4. See above.
13 – 1028	7 – 514	Cells 2 – 128 (if used)	These fields store correlation magnitude data for depth cells 2 through 128 (depending on the WN-command) for all four beams. These fields follow the same format as listed above for depth cell 1.

The echo intensity scale factor is about 0.45 dB per Navigator count. The Navigator does not directly check for the validity of echo intensity data.

Table 49: Echo Intensity Data Format

Hex Digit	Binary Byte	Field	Description
1 – 4	1,2	ID Code	Stores the echo intensity data identification word (00 03h).
5,6	3	Depth Cell 1, Field 1	Stores echo intensity data for depth cell #1, beam #1. See above.
7,8	4	Depth Cell 1, Field 2	Stores echo intensity data for depth cell #1, beam #2. See above.
9,10	5	Depth Cell 1, Field 3	Stores echo intensity data for depth cell #1, beam #3. See above.
11,12	6	Depth Cell 1, Field 4	Stores echo intensity data for depth cell #1, beam #4. See above.
13 – 1028	7 – 514	Cells 2 – 128 (if used)	These fields store echo intensity data for depth cells 2 through 128 (depending on the WN-command) for all four beams. These fields follow the same format as listed above for depth cell 1.

The percent-good data field is a data-quality indicator that reports the percentage (0 to 100) of good data collected for each depth cell of the velocity profile. The setting of the EX-command (Coordinate Transformation) determines how the Navigator references percent-good data as shown below.

EX-Command	Coord. Sys	Velocity 1	Velocity 2	Velocity 3	Velocity 4
			Percentage Of Good Pings For:		
		Beam 1	BEAM 2	BEAM 3	BEAM 4
xxx00xxx	Beam		Percentage Of:		
xxx01xxx xxx10xxx xxx11xxx	Inst Ship Earth	3-Beam Transformations (note 1)	Transformations Rejected (note 2)	More Than One Beam Bad In Bin	4-Beam Transformations

1. Because profile data did not exceed correlation threshold (WC).
2. Because the error velocity threshold (WE) was exceeded.

At the start of the velocity profile, the backscatter echo strength is typically high on all four beams. Under this condition, the Navigator uses all four beams to calculate the orthogonal and error velocities. As the echo returns from far away depth cells, echo intensity decreases. At some point, the echo will be weak enough on any given beam to cause the Navigator to reject some of its depth cell data. This causes the Navigator to calculate velocities with three beams instead of four beams. When the Navigator does 3-beam solutions, it stops calculating the error velocity because it needs four beams to do this. At some further depth cell, the Navigator rejects all cell data because of the weak echo. As an example, let us assume depth cell 60 has returned the following percent-good data.

```
FIELD #1 = 50, FIELD #2 = 5, FIELD #3 = 0, FIELD #4 = 45
```

If the EX-command was set to collect velocities in BEAM coordinates, the example values show the percentage of pings having good solutions in cell 60 for each beam based on the Low Correlation Threshold (WC-command). Here, beam 1=50%, beam 2=5%, beam 3=0%, and beam 4=45%. These are <u>not</u> typical nor desired percentages. Typically, you would want all four beams to be about equal and greater than 25%.

On the other hand, if velocities were collected in INSTRUMENT, SHIP, or EARTH coordinates, the example values show:

<u>FIELD 1 – Percentage of good 3-beam solutions</u> – Shows percentage of successful velocity calculations (50%) using 3-beam solutions because the correlation threshold (WC) was not exceeded.

<u>FIELD 2 – Percentage of transformations rejected</u> – Shows percent of error velocity (5%) that was less than the WE-command setting. WE has a default of 5000 mm/s. This large WE setting effectively prevents the Navigator from rejecting data based on error velocity.

FIELD 3 – Percentage of more than one beam bad in bin – 0% of the velocity data were rejected because not enough beams had good data.

FIELD 4 – Percentage of good 4-beam solutions – 45% of the velocity data collected during the ensemble for depth cell 60 were calculated using four beams.

Table 50: Percent-Good Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the percent-good data identification word (00 04h).
5,6	3	Depth cell 1, Field 1	Stores percent-good data for depth cell #1, field 1. See above.
7,8	4	Depth cell 1, Field 2	Stores percent-good data for depth cell #1, field 2. See above.
9,10	5	Depth cell 1, Field 3	Stores percent-good data for depth cell #1, field 3. See above.
11,12	6	Depth cell 1, Field 4	Stores percent-good data for depth cell #1, field 4. See above.
13-1028	7-514	Depth cell 2 – 128 (if used)	These fields store percent-good data for depth cells 2 through 128 (depending on the WN-command), following the same format as listed above for depth cell 1.

13.6 Binary Bottom-Track Data Format

BIT POSITIONS

BYTE	7/S 6 5 4 3 2 1 0	
1	BOTTOM-TRACK ID	LSB 00h
2		MSB 06h
3	BT PINGS PER ENSEMBLE {BP}	LSB
4		MSB
5	BT DELAY BEFORE RE-ACQUIRE {BD}	LSB
6		MSB
7	BT CORR MAG MIN {BC}	
8	BT EVAL AMP MIN {BA}	
9	BT PERCENT GOOD MIN {BG}	
10	BT MODE {BM}	
11	BT ERR VEL MAX {BE}	LSB
12		MSB
13	RESERVED	
14		
15		
16		
17	BEAM#1 BT RANGE	LSB
18		MSB
19	BEAM#2 BT RANGE	LSB
20		MSB
21	BEAM#3 BT RANGE	LSB
22		MSB
23	BEAM#4 BT RANGE	LSB
24		MSB
25	BEAM#1 BT VEL	LSB
26		MSB
27	BEAM#2 BT VEL	LSB
28		MSB
29	BEAM#3 BT VEL	LSB
30		MSB
31	BEAM#4 BT VEL	LSB
32		MSB

Continued Next Page

Continued from Previous Page

33	BEAM#1 BT CORR.	
34	BEAM#2 BT CORR.	
35	BEAM#3 BT CORR.	
36	BEAM#4 BT CORR.	
37	BEAM#1 EVAL AMP	
38	BEAM#2 EVAL AMP	
39	BEAM#3 EVAL AMP	
40	BEAM#4 EVAL AMP	
41	BEAM#1 BT %GOOD	
42	BEAM#2 BT %GOOD	
43	BEAM#3 BT %GOOD	
44	BEAM#4 BT %GOOD	
45	REF LAYER MIN {BL}	LSB
46		MSB
47	REF LAYER NEAR {BL}	LSB
48		MSB
49	REF LAYER FAR {BL}	LSB
50		MSB
51	BEAM#1 REF LAYER VEL	LSB
52		MSB
53	BEAM #2 REF LAYER VEL	LSB
54		MSB
55	BEAM #3 REF LAYER VEL	LSB
56		MSB
57	BEAM #4 REF LAYER VEL	LSB
58		MSB
59	BM#1 REF CORR	
60	BM#2 REF CORR	
61	BM#3 REF CORR	
62	BM#4 REF CORR	
63	BM#1 REF INT	
64	BM#2 REF INT	
65	BM#3 REF INT	
66	BM#4 REF INT	

Continued Next Page

Continued from Previous Page

67	BM#1 REF %GOOD	
68	BM#2 REF %GOOD	
69	BM#3 REF %GOOD	
70	BM#4 REF %GOOD	
71	BT MAX. DEPTH {BX}	LSB
72		MSB
73	BM#1 RSSI AMP	
74	BM#2 RSSI AMP	
75	BM#3 RSSI AMP	
76	BM#4 RSSI AMP	
77	GAIN	
78	(*SEE BYTE 17)	MSB
79	(*SEE BYTE 19)	MSB
80	(*SEE BYTE 21)	MSB
81	(*SEE BYTE 23)	MSB
82	RESERVED	
83		
84		
85		

Figure 48. Binary Bottom-Track Data Format

NOTE. This data is output only if the BP-command is > 0 and PD0 is selected. See Table 51, page 239 for a description of the fields.

NOTE. The PD0 output data format assumes that the **instrument** is stationary and the **bottom** is moving. DVL (Speed Log) output data formats (see "Special Output Data Formats," page 242) assume that the bottom is stationary and that the DVL or vessel is moving.

This data is output only if the BP-command is greater than zero and PD0 is selected. The LSB is always sent first.

Table 51: Bottom-Track Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the bottom-track data identification word (00 06h).
5-8	3,4	BP/BT Pings per ensemble	Stores the number of bottom-track pings to average together in each ensemble (BP-command). If BP = 0, the DVL does not collect bottom-track data. The DVL automatically extends the ensemble interval (TE) if BP x TP > TE. Scaling: LSD = 1 ping; Range = 0 to 999 pings
9-12	5,6	BD/BT delay before reacquire	Stores the number of DVL ensembles to wait after losing the bottom before trying to reacquire it (BD-command). Scaling: LSD = 1 ensemble; Range = 0 to 999 ensembles
13,14	7	BC/BT Corr Mag Min	Stores the minimum correlation magnitude value (BC-command). Scaling: LSD = 1 count; Range = 0 to 255 counts
15,16	8	BA/BT Eval Amp Min	Stores the minimum evaluation amplitude value (BA-command). Scaling: LSD = 1 count; Range = 1 to 255 counts
17,18	9	BG/BT %Gd Minimum	Stores the minimum percentage of bottom-track pings in an ensemble that must be good to output velocity data (BG-command).
19,20	10	BM/BT Mode	Stores the bottom-tracking mode (BM-command).
21-24	11,12	BE/BT Err Vel Max	Stores the error velocity maximum value (BE-command). Scaling: LSD = 1 mm/s; Range = 0 to 5000 mm/s (0 = did not screen data)
25-32	13–16	Reserved	Reserved
33-48	17-24	BT Range/Beam #1-4 BT Range	Contains the two lower bytes of the vertical distance from the unit to the bottom OR the vertical component of the range measured along each beam as determined by each beam. This vertical range does not consider the effects of pitch and roll. When bottom detections are bad, BT Range = zero. See bytes 78 through 81 for MSB description and scaling. Scaling: LSD = 1 cm; Range = 0 to 65535 cm
49-64	25-32	BT Velocity/Beam #1-4 BT Vel	The meaning of the velocity depends on the EX (coordinate system) command setting. The four velocities are as follows: a) Beam Coordinates: Beam 1, Beam 2, Beam 3, Beam 4 b) Instrument Coordinates: 1->2, 4->3, toward face, error c) Ship Coordinates: Starboard, Fwd, Upward, Error d) Earth Coordinates: East, North, Upward, Error
65-72	33-36	BTCM/Beam #1-4 BT Corr.	Contains the correlation magnitude in relation to the sea bottom (or surface) as determined by each beam. Bottom-track correlation magnitudes have the same format and scale factor as water-profiling magnitudes.

Continued Next Page

Table 51: Bottom-Track Data Format (continued)

Hex Digit	Binary Byte	Field	Description
73-80	37-40	BTEA/Beam #1-4 BT Eval Amp	Contains the evaluation amplitude of the matching filter used in determining the strength of the bottom echo. Scaling: LSD = 1 count; Range = 0 to 255 counts
81-88	41-44	BTPG/Beam #1-4 BT %Good	Contains bottom-track percent-good data for each beam, which indicate the reliability of bottom-track data. It is the percentage of bottom-track pings that have passed the DVL's bottom-track validity algorithm during an ensemble. Scaling: LSD = 1 percent; Range = 0 to 100 percent
89-92 93-96 97 – 100	45,46 47,48 49,50	Ref Layer (Min, Near, Far)	Stores the minimum layer size, the near boundary, and the far boundary of the BT water-reference layer ("BL - Water-Mass Layer Parameters ," page 143). Scaling (minimum layer size): LSD = 1 dm; Range = 0-999 dm Scaling (near/far boundaries): LSD = 1 dm; Range = 0-9999 dm
101-116	51-58	Ref Vel/Beam #1-4 Ref Layer Vel	Contains velocity data for the water reference layer for each beam. Reference layer velocities have the same format and scale factor as water-profiling velocities (Table 47, page 231). The BL-command explains the water reference layer.
117-124	59-62	RLCM/Bm #1-4 Ref Corr	Contains correlation magnitude data for the water reference layer for each beam. Reference layer correlation magnitudes have the same format and scale factor as water-profiling magnitudes (Table 5).
125-132	63-66	RLEI/Bm #1-4 Ref Int	Contains echo intensity data for the reference layer for each beam. Reference layer intensities have the same format and scale factor as water-profiling intensities.
133-140	67-70	RLPG/Bm #1-4 Ref %Good	Contains percent-good data for the water reference layer for each beam. They indicate the reliability of reference layer data. It is the percentage of bottom-track pings that have passed a reference layer validity algorithm during an ensemble. Scaling: LSD = 1 percent; Range = 0 to 100 percent
141-144	71,72	BX/BT Max. Depth	Stores the maximum tracking depth value ("BX – Maximum Tracking Depth," page 150). Scaling: LSD = 1 decimeter; Range = 80 to 9999 decimeters
145-152	73-76	RSSI/Bm #1-4 RSSI Amp	Contains the Receiver Signal Strength Indicator (RSSI) value in the center of the bottom echo as determined by each beam. Scaling: LSD ≈ 0.45 dB per count; Range = 0 to 255 counts
153, 154	77	GAIN	Contains the Gain level for shallow water. See "WJ - Receiver Gain Select," page 206.
155-162	78-81	BT Range MSB/Bm #1-4	Contains the most significant byte of the vertical distance from the unit to the bottom OR the vertical component of the range measured along each beam as determined by each beam. This vertical range does not consider the effects of pitch and roll. When bottom detections are bad, BT Range = zero. See bytes 17 through 24 for LSB description and scaling. Scaling: LSD = 65,536 cm, Range = 65,536 to 16,777,215 cm
163-170	82-85	Reserved	Reserved

13.7 Binary Reserved BIT Data Format

BIT POSITIONS

BYTE	7	6	5	4	3	2	1	0	
1	RESERVED FOR TRDI USE								LSB
2									MSB

Figure 49. Binary Reserved BIT Data Format

NOTE. The data is always output in this format. See Table 52 for a description of the fields.

Table 52: Reserved for TRDI Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Reserved for TRDI's use	This field is for TRDI (internal use only).

13.8 Binary Checksum Data Format

BIT POSITIONS

BYTE	7	6	5	4	3	2	1	0	
1	CHECKSUM DATA								LSB
2									MSB

Figure 50. Binary Checksum Data Format

NOTE. The data is always output in this format. See Table 53 for a description of the fields.

Table 53: Checksum Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Checksum Data	This field contains a modulo 65535 checksum. The Navigator computes the checksum by summing all the bytes in the output buffer excluding the checksum.

14 Special Output Data Formats

The PD3, PD4, PD5, PD6, PD10, PD11 and PD13 commands select the desired DVL (speed log) output data format.

The DVL binary output data buffers can contain header, configuration, bottom-velocity, water-mass reference-layer, range to bottom, status, built-in test, sensor, and distance made good data (plus a checksum). The DVL collects all data in the output buffer during an ensemble.

Figure 51, page 244 through Figure 53, page 253shows the format of these buffers and the sequence in which the DVL sends the data. Table 59, page 263 list the format, bytes, fields, scaling factors, and a detailed description of every item in the DVL binary output buffers.

NOTE. The DVL output data formats are available with or without bottom-track. However, if bottom-track is not available, they will contain no data.

NOTE. The DVL output data formats assume that the bottom is stationary and that the DVL or vessel is moving. The PD0 Bottom Track output data format (see "Binary Bottom-Track Data Format," page 236) assumes that the instrument is stationary and the bottom is moving.

14.1 DVL Binary Data Format (PD3)

BIT POSITION

Byte	7	6	5	4	3	2	1	0	
1	DVL DATA ID 7Eh								
2	DATA STRUCTURE*								
3	STARBOARD/EAST VELOCITY (With Respect To BTM)								LSB
4									MSB
5	FORWARD/NORTH VELOCITY (With Respect To BTM)								LSB
6									MSB
7	UPWARD VELOCITY (With Respect To BTM)								LSB
8									MSB
9	STARBOARD/EAST VELOCITY (With Respect To WATER REF)								LSB
10									MSB
11	FORWARD/NORTH VELOCITY (With Respect To WATER REF)								LSB
12									MSB
13	UPWARD VELOCITY (With Respect To WATER REF)								LSB
14									MSB
15	BM1 RNG TO BTM								LSB
16									MSB
17	BM2 RNG TO BTM								LSB
18									MSB
19	BM3 RNG TO BTM								LSB
20									MSB
21	BM4 RNG TO BTM								LSB
22									MSB
23	RANGE TO BTM (AVERAGE)								LSB
24									MSB
25	SPARE								
↓									↓
↓									↓
40									

Continued next page

Continued from Previous Page

41	SENSOR/OTHER DATA	
42	PING TIME: HOUR	
43	MINUTE	
44	SECOND	
45	HUNDREDTH	
46	HEADING	LSB
47		MSB
48	PITCH	LSB
49		MSB
50	ROLL	LSB
51		MSB
52	TEMPERATURE	LSB
53		MSB
54	BIT RESULTS	LSB
55		MSB
56	CHECKSUM	LSB
57		MSB

Figure 51. DVL Binary Data Format (PD3)

14.2 DVL Output Data Format (PD3) Details

The DVL sends this data format only when the PD3 command is used. In multiple byte parameters, the least significant byte always comes before the more significant bytes.

Table 54: DVL Output Data Format (PD3) Details

Hex Digit	Binary Byte	Field	Description
1,2	1	DVL Data ID	Stores the DVL (speed log) identification word (7Eh)
3,4	2	Reserved	Reserved
5-8	3,4	X-Vel Btm	† Bit #0: Always output. If the data bit is set to 0, then Ship coordinates are used. If the data bit is set to 1, then Earth coordinates are used. These fields contain the velocity of the vessel in relation to the bottom in mm/s. Positive values indicate vessel motion to (X) Starboard/East, (Y) Forward/North, (Z) Upward.
9-12	5,6	Y-Vel Btm	
13-16	7,8	Z-Vel Btm	† Bit #1: Vertical velocities.
17-20	9,10	X-Vel Water	† Bit #2: These fields contain the velocity of the vessel in relation to the water reference layer in mm/s. Positive values indicate vessel motion to (X) Starboard/East, (Y) Forward/North, (Z) Upward.
21-24	11,12	Y-Vel Water	
25-28	13,14	Z-Vel Water	† Bit #1 and Bit #2
29-32	15,16	Bm1	† Bit #3: These fields contain the vertical range from the DVL to the bottom as determined by each beam. This vertical range does not compensate for the effects of pitch and roll. When a bottom detection is bad, the field is set to zero.
33-36	17,18	Bm2 Rng to	
37-40	19,20	Bm3 Bottom	
41-44	21,22	Bm4	Scaling: LSD = 1 centimeter; Range = 0 to 65535 cm
45-48	23,24	Avg Rng to Btm	† Bit #4: These fields contain the average vertical range from the DVL to the bottom as determined by each beam.

Continued next page

Table 54: DVL Output Data Format (PD3) Details (continued)

Hex Digit	Binary Byte	Field	Description
49-80	25-40	Spare	Spare

81,82	41	Sensor/Other Data	† Output if Bit #7 of "Data to Follow" byte is set. These fields contain the Sensor/Other data.
			`Bit #`
			`0 = Time`
			`1 = Heading`
			`2 = Pitch`
			`3 = Roll`
			`4 = Temperature`
			`5 = Active Built-In-Test`

83-90	42,43	Time: HH,MM	‡ Sensor/Other Data Bit #0: These fields contains the time of the ping in Hours, Minutes Seconds, Hundredths of seconds respectively.
	44,45	Time: SS,HH	
91-94	46,47	Heading	‡ Sensor/Other Data Bit #1: this field contains the Heading in hundredths of degrees.
95-98	48,49	Pitch	‡ Sensor/Other Data Bit #2: this field contains the Pitch in hundredths of degrees.
99-102	50,51	Roll	‡ Sensor/Other Data Bit #3: this field contains the Roll in hundredths of degrees.
103-106	52,53	Temp	‡ Sensor/Other Data Bit #4: this field contains the Temperature in hundredths of degrees.

107-110	54,55	BIT results	‡ Sensor/Other Data Bit #5: this field contains the Built-In-Test results. Each bit specifies the result of built-in-test during an ensemble. If the bit is set, the test failed.
			`BYTE 54 BYTE 55 (BYTE 55 RESERVED FOR FUTURE USE)`
			`1xxxxxxx xxxxxxxx = RESERVED`
			`x1xxxxxx xxxxxxxx = RESERVED`
			`xx1xxxxx xxxxxxxx = RESERVED`
			`xxx1xxxx xxxxxxxx = DEMOD 1 ERROR`
			`xxxx1xxx xxxxxxxx = DEMOD 0 ERROR`
			`xxxxx1xx xxxxxxxx = RESERVED`
			`xxxxxx1x xxxxxxxx = DSP ERROR`
			`xxxxxxx1 xxxxxxxx = RESERVED`

111-114	56,57	Checksum	This is the 16-bit checksum of all the preceding binary bytes.

NOTES.

† This block of data is only output if the bit is set in the Data to Follow byte.

‡ This block of data is only output if the bit is set in the Sensor/Other Data byte.

14.3 DVL Binary Data Format (PD4/PD5)

BIT POSITION

Byte	7	6	5	4	3	2	1	0	
1	DVL DATA ID 7Dh								
2	DATA STRUCTURE*								
3	NO. OF BYTES								LSB
4									MSB
5	SYSTEM CONFIG								
6	X-VEL BTM								LSB
7									MSB
8	Y-VEL BTM								LSB
9									MSB
10	Z-VEL BTM								LSB
11									MSB
12	E-VEL BTM								LSB
13									MSB
14	BM1 RNG TO BTM								LSB
15									MSB
16	BM2 RNG TO BTM								LSB
17									MSB
18	BM3 RNG TO BTM								LSB
19									MSB
20	BM4 RNG TO BTM								LSB
21									MSB
22	BOTTOM STATUS								
23	X-VEL REF LAYER								LSB
24									MSB
25	Y-VEL REF LAYER								
26									
27	Z-VEL REF LAYER								
28									

Continued Next Page

Continued from Previous Page

Byte	Field
29	E-VEL REF LAYER
30	
31	REF LAYER START
32	
33	REF LAYER END
34	
35	REF LAYER STATUS
36	TOFP-HOUR
37	TOFP-MINUTE
38	TOFP-SECOND
39	TOFP-HUNDREDTHS
40	BIT RESULTS
41	
42	SPEED OF SOUND
43	
44	TEMPERATURE
45	
46	CHECKSUM
47	

Figure 52. DVL Binary Data Format (PD4/PD5)

NOTES.

*IF 0, THEN PD4 (BYTES 1-47)

*IF 1, THEN PD5 (BYTES 1-45 + TABLE 9)

14.4 DVL Output Data Format (PD4/PD5) Details

The DVL sends this data format only when the PD4 or PD5 command is used.

Table 55: DVL Output Data Format (PD4/PD5) Details

Hex Digit	Binary Byte	Field	Description
1,2	1	DVL Data ID	Stores the DVL (speed log) identification word (7Dh).
3,4	2	Data Structure	Identifies which data pattern will follow based on the PD- command. 0 = PD4 = Bytes 1 through 47 from Figure 52, page 248. 1 = PD5 = Bytes 1 through 45 from Figure 52, page 248 and bytes 46 through 88 from Figure 53, page 253. Note: PD6 is ASCII-only; see Table 57, page 255.
5-8	3,4	No. of Bytes	Contains the number of bytes sent in this data structure, not including the final checksum.

9,10	5	System Config	Defines the DVL hardware/firmware configuration. Convert to binary and interpret as follows.
			`BIT 76543210`
			`00xxxxxx BEAM-COORDINATE VELOCITIES`
			`01xxxxxx INSTRUMENT-COORDINATE VELOCITIES`
			`10xxxxxx SHIP-COORDINATE VELOCITIES`
			`11xxxxxx EARTH-COORDINATE VELOCITIES`
			`xx0xxxxx TILT INFORMATION NOT USED IN CALCULATIONS`
			`xx1xxxxx TILT INFORMATION USED IN CALCULATIONS`
			`xxx0xxxx 3-BEAM SOLUTIONS NOT COMPUTED`
			`xxx1xxxx 3-BEAM SOLUTIONS COMPUTED`
			`xxxxx010 300-kHz DVL`
			`xxxxx011 600-kHz DVL`
			`xxxxx100 1200-kHz DVL`

11-14	6,7	X-Vel Btm	These fields contain the velocity of the vessel in relation to the bottom in mm/s. Positive values indicate vessel motion to east (X), north (Y), and up (Z). LSD = 1 mm/s (see NOTES at end of this table).
15-18	8,9	Y-Vel Btm	
19-22	10,11	Z-Vel Btm	
23-26	12,13	E-Vel Btm	
27-30	14,15	Bm1	These fields contain the vertical range from the DVL to the bottom as determined by each beam. This vertical range does not compensate for the effects of pitch and roll. When a bottom detection is bad, the field is set to zero.
31-34	16,17	Bm2 Rng to	
35-38	18,19	Bm3 Bottom	
39-42	20,21	Bm4	Scaling: LSD = 1 centimeter; Range = 0 to 65535 cm

Continued next page

Table 55: DVL Output Data Format (PD4/PD5) Details (continued)

Hex Digit	Binary Byte	Field	Description

43,44	22	Bottom Status	This field shows the status of bottom-referenced correlation and echo amplitude data. Convert to binary and interpret as follows. A zero code indicates status is OK.
			`BIT 76543210`
			`1xxxxxxx BEAM 4 LOW ECHO AMPLITUDE`
			`x1xxxxxx BEAM 4 LOW CORRELATION`
			`xx1xxxxx BEAM 3 LOW ECHO AMPLITUDE`
			`xxx1xxxx BEAM 3 LOW CORRELATION`
			`xxxx1xxx BEAM 2 LOW ECHO AMPLITUDE`
			`xxxxx1xx BEAM 2 LOW CORRELATION`
			`xxxxxx1x BEAM 1 LOW ECHO AMPLITUDE`
			`xxxxxxx1 BEAM 1 LOW CORRELATION`

45-48	23,24	X-Vel Ref Layer	These fields contain the velocity of the vessel in relation to the water-mass reference layer in mm/s. Positive values indicate vessel motion to east (X), north (Y), and up (Z). LSD = 1 mm/s (See NOTES at end of this table.)
49-52	25,26	Y-Vel Ref Layer	
53-56	27,28	Z-Vel Ref Layer	
57-60	29,30	E-Vel Ref Layer	
61-64	31,32	Ref Layer Start	These fields contain the starting boundary (near surface) and the ending boundary (near bottom) of the water-mass reference layer (BL-command). If the minimum size field is zero, the DVL does not calculate reference-layer data. Scaling: LSD = 1 dm; Range = 0-9999 dm
65-68	33,34	Ref Layer End	

69,70	35	Ref Layer Status	This field shows the status of reference layer depth and correlation data. Convert to binary and interpret as follows. A zero code indicates status is OK.
			`BIT 76543210`
			`xxx1xxxx ALTITUDE IS TOO SHALLOW`
			`xxxx1xxx BEAM 4 LOW CORRELATION`
			`xxxxx1xx BEAM 3 LOW CORRELATION`
			`xxxxxx1x BEAM 2 LOW CORRELATION`
			`xxxxxxx1 BEAM 1 LOW CORRELATION`

71,72	36	TOFP Hour	These fields contain the time of the first ping of the current ensemble.
73,74	37	TOFP Minute	
75,76	38	TOFP Second	
77,78	39	TOFP Hundredth	

79-82	40,41	BIT Results	These fields contain the results of the DVL's Built-in Test function. A zero code indicates a successful BIT result.
			`BYTE 40  BYTE 41 (BYTE 41 RESERVED FOR FUTURE USE)`
			`1xxxxxxx xxxxxxxx = RESERVED`
			`x1xxxxxx xxxxxxxx = RESERVED`
			`xx1xxxxx xxxxxxxx = RESERVED`
			`xxx1xxxx xxxxxxxx = DEMOD 1 ERROR`
			`xxxx1xxx xxxxxxxx = DEMOD 0 ERROR`
			`xxxxx1xx xxxxxxxx = RESERVED`
			`xxxxxx1x xxxxxxxx = DSP ERROR`
			`xxxxxxx1 xxxxxxxx = RESERVED`

83-86	42,43	Speed of Sound	Contains either manual or calculated speed of sound information (EC-command). Scaling: LSD = 1 meter per second; Range = 1400 to 1600 m/s
87-90	44,45	Temperature	Contains the temperature of the water at the transducer head. Scaling: LSD = 0.01 C; Range = -5.00 to +40.00 C

Table 55: DVL Output Data Format (PD4/PD5) Details (continued)

Hex Digit	Binary Byte	Field	Description
91-94	46,47	Checksum	This field contains a modulo 65536 checksum. The DVL computes the checksum by summing all the bytes in the output buffer excluding the checksum. NOTE: This field contains the checksum only when the PD4-command is used. If PD5 is used, the remaining bytes are explained in Table 56, page 254.

NOTES.

The DVL packs velocity data into a two-byte, two's-complement integer [-32768, 32767] with the LSB sent first. The DVL scales velocity data in millimeters per second (mm/s). A value of –32768 (8000h) indicates a bad velocity.

Bottom or reference-layer velocities will be all valid or all invalid. That is, if the X-velocity is valid then the Y and Z-velocities are valid; if X is not valid, Y and Z are not valid.

The DVL allows 3-beam transformations when the fourth beam is invalid. Indication of a 3-beam transformation for bottom-track is valid bottom velocities and one and only one beam's range to bottom is marked bad (zero).

There is no indication that a 3-beam transformation was performed for water reference layer velocity data.

14.5 DVL Binary Data Format (PD5)

BIT POSITION

Byte	7	6	5	4	3	2	1	0	
46	SALINITY								
47	DEPTH								LSB
48									MSB
49	PITCH								LSB
50									MSB
51	ROLL								LSB
52									MSB
53	HEADING								LSB
54									MSB
55	DISTANCE MADE GOOD/BTM (EAST)								LSB
56									
57									
58									MSB
59	DISTANCE MADE GOOD/BTM (NORTH)								LSB
60									
61									
62									MSB
63	DISTANCE MADE GOOD/BTM (UP)								LSB
64									
65									
66									MSB
67	DISTANCE MADE GOOD/BTM (ERROR)								LSB
68									
69									
70									MSB
71	DISTANCE MADE GOOD/REF (EAST)								LSB
72									
73									
74									MSB

Continued Next Page

Continued from Previous Page

75	DISTANCE MADE GOOD/REF (NORTH)	LSB
76		
77		
78		MSB
79	DISTANCE MADE GOOD/REF (UP)	LSB
80		
81		
82		MSB
83	DISTANCE MADE GOOD/REF (ERROR)	LSB
84		
85		
86		MSB
87	CHECKSUM	LSB
88		MSB

Figure 53. DVL Binary Data Format (PD5)

14.6 DVL Output Data Format (PD5) Details

The DVL sends this data format (Figure 52, page 248 and Figure 53, page 253) only when the PD5 command is used. Table 55, page 249 explains the first part of this data structure.

Table 56: DVL Output Data Format (PD5) Details

Hex Digit	Binary Byte	Field	Description
91,92	46	Salinity	Contains the salinity value of the water at the transducer head (ES-command). This value may be a manual setting or a reading from a conductivity sensor. Scaling: LSD = 1 part per thousand; Range = 0 to 40 ppt
93-96	47,48	Depth	Contains the depth of the transducer below the water surface (ED-command). This value may be a manual setting or a reading from a depth sensor. Scaling: LSD = 1 decimeter; Range = 1 to 9999 decimeters
97-100	49,50	Pitch	Contains the DVL pitch angle (EP-command). This value may be a manual setting or a reading from a tilt sensor. Positive values mean that Beam #3 is spatially higher than Beam #4. Scaling: LSD = 0.01 degree; Range = -20.00 to +20.00 degrees
101-104	51,52	Roll	Contains the DVL roll angle (ER-command). This value may be a manual setting or a reading from a tilt sensor. For up-facing DVLs, positive values mean that Beam #2 is spatially higher than Beam #1. For down-facing DVLs, positive values mean that Beam #1 is spatially higher than Beam #2. Scaling: LSD = 0.01 degree; Range = -20.00 to +20.00 degrees
105-108	53,54	Heading	Contains the DVL heading angle (EH-command). This value may be a manual setting or a reading from a heading sensor. Scaling: LSD = 0.01 degree; Range = 000.00 to 359.99 degrees
109-116	55-58	DMG/Btm East	These fields contain the Distance Made Good (DMG) over the bottom since the time of the first ping after initialization or <BREAK>. Scaling: LSD = 1 dm; Range = -10,000,000 to 10,000,000 dm
117-124	59-62	DMG/Btm North	
125-132	63-66	DMG/Btm Up	
133-140	67-70	DMG/Btm Error	
141-148	71-74	DMG/Ref East	These fields contain the distance made good over the water-mass reference layer since the time of the first ping after initialization or <BREAK>. Scaling: LSD = 1 dm; Range = -10,000,000 to 10,000,000 dm
149-156	75-78	DMG/Ref North	
157-164	79-82	DMG/Ref Up	
165-172	83-86	DMG/Ref Error	
173-176	87,88	Checksum	This field contains a modulo 65536 checksum. The DVL computes the checksum by summing all the bytes in the output buffer excluding the checksum.

14.7 DVL Output Data Format (PD6)

The DVL sends this data format only when the PD6 command is used. The DVL outputs data in the following line order. The DVL may not sent all data lines. Examples: (1) If BK = zero, the DVL does not send water-mass data (line items beginning with W); (2) If BK = three, the DVL does not send bottom-track data (line items beginning with B).

Table 57: DVL Output Data Format (PD6)

Line	Description
1	**SYSTEM ATTITUDE DATA** **:SA,±PP.PP,±RR.RR,HH.HH <CR><LF>** where: PP.PP = Pitch in degrees RR.RR = Roll in degrees HHH.HH = Heading in degrees
2	**TIMING AND SCALING DATA** **:TS,YYMMDDHHmmsshh,SS.S,+TT.T,DDDD.D,CCCC.C,BBB <CR><LF>** where: YYMMDDHHmmsshh = Year, month, day, hour, minute, second, hundredths of seconds SS.S = Salinity in parts per thousand (ppt) TT.TT = Temperature in C DDDD.D = Depth of transducer face in meters CCCC.C = Speed of sound in meters per second BBB = Built-in Test (BIT) result code
3	**WATER-MASS, INSTRUMENT-REFERENCED VELOCITY DATA** **:WI,±XXXXX,±YYYYY,±ZZZZZ,±EEEEE,S <CR><LF>** where: ±XXXXX = X-axis vel. data in mm/s (+ = Bm1 Bm2 xdcr movement relative to water mass) ±YYYYY = Y-axis vel. data in mm/s (+ = Bm4 Bm3 xdcr movement relative to water mass) ±ZZZZZ = Z-axis vel. data in mm/s (+ = transducer movement away from water mass) ±EEEEE = Error velocity data in mm/s S = Status of velocity data (A = good, V = bad)
4	**WATER-MASS, SHIP-REFERENCED VELOCITY DATA** **:WS,±TTTTT,±LLLLL,±NNNNN,S <CR><LF>** where: ±TTTTT = Transverse vel. data in mm/s (+ = Port Stbd ship movement rel. to water mass) ±LLLLL = Longitudinal vel. data in mm/s (+ = Aft Fwd ship movement rel. to water mass) ±NNNNN = Normal velocity data in mm/s (+ = ship movement away from water mass) S = Status of velocity data (A = good, V = bad)
5	**WATER-MASS, EARTH-REFERENCED VELOCITY DATA** **:WE,±EEEEE,±NNNNN,±UUUUU,S <CR><LF>** where: ±EEEEE = East (u-axis) velocity data in mm/s (+ = DVL movement to east) ±NNNNN = North (v-axis) velocity data in mm/s (+ = DVL movement to north) ±UUUUU = Upward (w-axis) velocity data in mm/s (+ = DVL movement to surface) S = Status of velocity data (A = good, V = bad)

Continued next page

Table 57: DVL Output Data Format (PD6) (continued)

Line	Description
6	**WATER-MASS, EARTH-REFERENCED DISTANCE DATA** **:WD,±EEEEEEEE.EE,±NNNNNNNN.NN,±UUUUUUUU.UU,DDDD.DD,TTT.TT <CR><LF>** where: +EEEEEEEE.EE = East (u-axis) distance data in meters +NNNNNNNN.NN = North (v-axis) distance data in meters +UUUUUUUU.UU = Upward (w-axis) distance data in meters DDDD.DD = Range to water-mass center in meters TTT.TT = Time since last good-velocity estimate in seconds
7	**BOTTOM-TRACK, INSTRUMENT-REFERENCED VELOCITY DATA** **:BI,±XXXXX,±YYYYY,±ZZZZZ,±EEEEE,S <CR><LF>** where: ±XXXXX = X-axis velocity data in mm/s (+ = Bm1 Bm2 xdcr movement relative to bottom) ±YYYYY = Y-axis velocity data in mm/s (+ = Bm4 Bm3 xdcr movement relative to bottom) ±ZZZZZ = Z-axis velocity data in mm/s (+ = transducer movement away from bottom) ±EEEEE = Error velocity data in mm/s S = Status of velocity data (A = good, V = bad)
8	**BOTTOM-TRACK, SHIP-REFERENCED VELOCITY DATA** **:BS,±TTTTT,±LLLLL,±NNNNN,S <CR><LF>** where: ±TTTTT = Transverse vel. data in mm/s (+ = Port Stbd ship movement relative to bottom) ±LLLLL = Longitudinal vel. data in mm/s (+ = Aft Fwd ship movement relative to bottom) ±NNNNN = Normal velocity data in mm/s (+ = ship movement away from bottom) S = Status of velocity data (A = good, V = bad)
9	**BOTTOM-TRACK, EARTH-REFERENCED VELOCITY DATA** **:BE,±EEEEE,±NNNNN,±UUUUU,S <CR><LF>** where: ±EEEEE = East (u-axis) velocity data in mm/s (+ = DVL movement to east) ±NNNNN = North (v-axis) velocity data in mm/s (+ = DVL movement to north) ±UUUUU = Upward (w-axis) velocity data in mm/s (+ = DVL movement to surface) S = Status of velocity data (A = good, V = bad)
10	**BOTTOM-TRACK, EARTH-REFERENCED DISTANCE DATA** **:BD,±EEEEEEEE.EE,±NNNNNNNN.NN,±UUUUUUUU.UU,DDDD.DD,TTT.TT <CR><LF>** where: +EEEEEEEE.EE = East (u-axis) distance data in meters +NNNNNNNN.NN = North (v-axis) distance data in meters +UUUUUUUU.UU = Upward (w-axis) distance data in meters DDDD.DD = Range to bottom in meters TTT.TT = Time since last good-velocity estimate in seconds

The PD6 output does not pad spaces with zeroes. The spaces are left intact. The example below shows a realistic output from a Navigator locked onto the bottom.

```
:SA,  -2.31,  +1.92, 75.20
:TS,04081111563644,35.0,+21.0,   0.0,1524.0,  0
:WI,-32768,-32768,-32768,-32768,V
:BI,   +24,    -6,   -20,    -4,A
:WS,-32768,-32768,-32768,V
:BS,   -13,   +21,   -20,A
:WE,-32768,-32768,-32768,V
:BE,   +17,   +18,   -20,A
:WD,       +0.00,       +0.00,       +0.00,  20.00,  0.00
:BD,       -0.02,       -0.03,       +0.02,   7.13,  0.21
```

14.8 DVL Binary Data Format (PD10)

BYTE	BIT POSITION 7	6	5	4	3	2	1	0	
1	DVL DATA ID 78h								
2	DATA STRUCTURE*								
3	STARBOARD/EAST VELOCITY (With Respect To BTM)								LSB
4									MSB
5	FORWARD/NORTH VELOCITY (With Respect To BTM)								LSB
6									MSB
7	UPWARD VELOCITY (With Respect To BTM)								LSB
8									MSB
9	STARBOARD/EAST VELOCITY (With Respect To WATER REF)								LSB
10									MSB
11	FORWARD/NORTH VELOCITY (With Respect To WATER REF)								LSB
12									MSB
13	UPWARD VELOCITY (With Respect To WATER REF)								LSB
14									MSB
15	BM1 RNG TO BTM								LSB
16									MSB
17	BM2 RNG TO BTM								LSB
18									MSB
19	BM3 RNG TO BTM								LSB
20									MSB
21	BM4 RNG TO BTM								LSB
22									MSB
23	RANGE TO BTM (AVERAGE)								LSB
24									MSB
25	SPARE								
↓									↓
↓									↓
40									
41	SENSOR/OTHER DATA								
42	PING TIME : HOUR								
43	MINUTE								
44	SECOND								
45	HUNDREDTH								
46	HEADING								LSB
47									MSB

Continued next Page

Continued from Previous Page

BYTE	BIT POSITION 7	6	5	4	3	2	1	0	
48	PITCH								LSB
49									MSB
50	ROLL								LSB
51									MSB
52	TEMPERATURE								LSB
53									MSB
54	BIT RESULTS								LSB
55									MSB
56	DEPTH								LSB
57									
58									
59									MSB
60	DEPTH STANDARD DEVIATION								LSB
61									
62									
63									MSB
64	CHECKSUM								LSB
65									MSB

Figure 54. DVL Binary Data Format (PD10)

NOTE. Navigator DVLs must have firmware 9.13 or later in order to use PD10 Output Data Format.

14.9 DVL Output Data Format (PD10) Details

The DVL sends this data format only when the PD10 command is used. In multiple byte parameters, the least significant byte always comes before the more significant bytes.

> **NOTE.** Navigator DVLs must have firmware 9.13 or later in order to use PD10 Output Data Format.

Table 58: DVL Output Data Format (PD10) Details

Hex Digit	Binary Byte	Field	Description
1,2	1	DVL Data ID	Stores the DVL (speed log) identification word (78h)
3,4	2	Reserved	Reserved
5-8	3,4	X-Vel Btm	† Bit #0: Always output. If the data bit is set to 0, then Ship co-ordinates are used. If the data bit is set to 1, then Earth coordinates are used. These fields contain the velocity of the vessel in relation to the bottom in mm/s. Positive values indicate vessel motion to (X) Starboard/East, (Y) Forward/North, and (Z) Upward.
9-12	5,6	Y-Vel Btm	
13-16	7,8	Z-Vel Btm	† Bit #1: Vertical velocities.
17-20	9,10	X-Vel Water	† Bit #2: These fields contain the velocity of the vessel in relation to the water reference layer in mm/s. Positive values indicate vessel motion to (X) Starboard/East, (Y) Forward/North, (Z) Upward.
21-24	11,12	Y-Vel Water	
25-28	13,14	Z-Vel Water	† Bit #1 and Bit #2
29-32	15,16	Bm1	† Bit #3: These fields contain the vertical range from the DVL to the bottom as determined by each beam. This vertical range does not compensate for the effects of pitch and roll. When a bottom detection is bad, the field is set to zero.
33-36	17,18	Bm2 Rng to	
37-40	19,20	Bm3 Bottom	
41-44	21,22	Bm4	Scaling: LSD = 1 centimeter; Range = 0 to 65535 cm

Continued Next Page

Table 58: DVL Output Data Format (PD10) Details (continued)

Hex Digit	Binary Byte	Field	Description
45-48	23,24	Avg Rng to Btm	† Bit #4: These fields contain the average vertical range from the DVL to the bottom as determined by each beam.
49-80	25-40	Spare	Spare

81,82	41	Sensor/Other Data	† Output if Bit #7 of "Data to Follow" byte is set. These fields contain the Sensor/Other data.
			`Bit #`
			`0 = Time`
			`1 = Heading`
			`2 = Pitch`
			`3 = Roll`
			`4 = Temperature`
			`5 = Active Built-In-Test`

83-90	42,43	Time: HH,MM	‡ Sensor/Other Data Bit #0: These fields contains the time of the ping in Hours, Minutes Seconds, Hundredths of seconds respectively.
	44,45	Time: SS,HH	
91-94	46,47	Heading	‡ Sensor/Other Data Bit #1: These fields contains the Heading in hundredths of degrees.
95-98	48,49	Pitch	‡ Sensor/Other Data Bit #2: These fields contains the Pitch in hundredths of degrees.
99-102	50,51	Roll	‡ Sensor/Other Data Bit #3: These fields contains the Roll in hundredths of degrees.
103-106	52,53	Temp	‡ Sensor/Other Data Bit #4: These fields contains the Tempera-ture in hundredths of degrees.

107-110	54,55	BIT results	‡ Sensor/Other Data Bit #5: These fields contains the Built-In-Test results. Each bit specifies the result of built-in-test during an ensemble. If the bit is set, the test failed.
			`BYTE 54   BYTE 55  (BYTE 55 RESERVED FOR FUTURE USE)`
			`1xxxxxxx xxxxxxxx = RESERVED`
			`x1xxxxxx xxxxxxxx = RESERVED`
			`xx1xxxxx xxxxxxxx = RESERVED`
			`xxx1xxxx xxxxxxxx = DEMOD 1 ERROR`
			`xxxx1xxx xxxxxxxx = DEMOD 0 ERROR`
			`xxxxx1xx xxxxxxxx = RESERVED`
			`xxxxxx1x xxxxxxxx = DSP ERROR`
			`xxxxxxx1 xxxxxxxx = RESERVED`

111-118	56-59	Depth	Depth data in decimeters.
119-126	60-63	Depth Std Dev.	Standard deviation of depth in decimeters
127-130	64,65	Checksum	This is the 16-bit checksum of all the preceding binary bytes.

14.10 Navigator NMEA Output (PD11)

The DVL sends this data format only when the PD11 command is used. Data will continue to be recorded to the internal recorder in PD0 format if the recording bit is set in the CF command. Note that the DVL will ignore the serial output bit in the CF command when PD11 is set.

> **NOTE.** In order to get valid water-reference data, BK1 must be set in the DVL.

There are presently three sentences containing sensor and navigational data.

> **NOTE.** TRDI may add additional sentences in the future so care should be taken to correctly identify the sentence by it's ID. In addition, TRDI may add fields to the existing sentences. Any such additional fields will be added after the last field and before the checksum. Care should be taken to locate the checksum by the '*' that immediately precedes it.

Sensor Data

The sensor data sentence consists of heading, pitch, roll, and depth below surface. Each data field is preceded by an identifier indicating the contents of the following fields. All values are in SI units. All data fields are variable width. Empty data fields will indicate missing or invalid data.

```
$PRDIG,H,x.x,P,x.x,R,x.x,D,x.x*hh<CR><LF>
   │   │  │  │  │  │  │  │  └ depth
   │   │  │  │  │  │  │  └ depth ID
   │   │  │  │  │  │  └ roll
   │   │  │  │  │  └ roll ID
   │   │  │  │  └ pitch
   │   │  │  └ pitch ID
   │   │  └ heading
   │   └ heading ID
   └ NMEA 0183 header
```

Bottom-Track Navigational Data

The bottom-track data sentence consists of range to the bottom, speed over ground, and course over ground. Each data field is preceded by an identifier indicating the contents of the following field. All values are in SI units. All data fields are variable width. Empty data fields will indicate missing or invalid data.

```
$PRDIH,R,x.x,S,x.x,C,x.x*hh<CR><LF>
   │   │  │  │  │  │  └ course over ground
   │   │  │  │  │  └ course over ground ID
   │   │  │  │  └ speed over ground
   │   │  │  └ speed over ground ID
   │   │  └ range to bottom
   │   └ range to bottom ID
   └ NMEA 0183 header
```

Current Referenced Navigational Data

The current referenced navigational data sentence shall consist of speed relative to the water current and course relative to the water current. Each data field will be preceded by an identifier indicating the contents of the following field. All values are in SI units. All data fields are variable width. Empty data fields will indicate missing or invalid data.

```
$PRDII,S,x.x,C,x.x*hh<CR><LF>
   |    |  |  |  └ course relative to current
   |    |  |  └ course relative to current ID
   |    |  └ speed relative to current
   |    └ speed relative to current ID
   └ NMEA 0183 header
```

Below is an example of a valid sensor data sentence showing a heading of 197.34°, a pitch angle of -10.2°, a roll angle of -11.5° and a depth of 122.7m.

```
$PRDIG,H,197.34,P,-10.2,R,-11.5,D,122.7*7E<CR><LF>
```

This example shows a valid bottom-track sentence that contains range to bottom of 143.2m, a speed over ground of 1.485 m/s, and a course over ground of 192.93°.

```
$PRDIH,R,143.2,S,1.485,C,192.93*17<CR><LF>
```

Here is an example of a bottom-track sentence with invalid or missing data.

```
$PRDIH,R,,S,,C,*05<CR><LF>
```

This last example shows a water-reference sentence that contains speed relative to current of 1.503 m/s and a course relative to current of 203.5°.

```
$PRDII,S,1.503,C,203.5*55<CR><LF>
```

14.11 DVL Output Data Format (PD13)

The DVL sends this data format only when the PD13 command is used. The DVL outputs data in the following line order. The DVL may not sent all data lines. Examples: (1) If BK = zero, the DVL does not send water-mass data (line items beginning with W); (2) If BK = three, the DVL does not send bottom-track data (line items beginning with B).

Table 59: DVL Output Data Format (PD13)

Line	Description
1	**SYSTEM ATTITUDE DATA** **:SA,±PP.PP,±RR.RR,HH.HH <CR><LF>** where: PP.PP = Pitch in degrees RR.RR = Roll in degrees HHH.HH = Heading in degrees
2	**TIMING AND SCALING DATA** **:TS,YYMMDDHHmmsshh,SS.S,+TT.T,DDDD.D,CCCC.C,BBB <CR><LF>** where: YYMMDDHHmmsshh = Year, month, day, hour, minute, second, hundredths of seconds SS.S = Salinity in parts per thousand (ppt) TT.TT = Temperature in C DDDD.D = Depth of transducer face in meters CCCC.C = Speed of sound in meters per second BBB = Built-in Test (BIT) result code
3	**PRESSURE AND RANGE TO BOTTOM DATA** **:RA,PPP.PP,RRRR.RR,RRRR.RR,RRRR.RR,RRRR.RR** where: PPP.PP = Pressure in kPa RRRR.RR = Range to the bottom in deci-meters Beam 1, Beam 2, Beam 3, Beam 4
4	**WATER-MASS, INSTRUMENT-REFERENCED VELOCITY DATA** **:WI,±XXXXX,±YYYYY,±ZZZZZ,±EEEEE,S <CR><LF>** where: ±XXXXX = X-axis vel. data in mm/s (+ = Bm1 Bm2 xdcr movement relative to water mass) ±YYYYY = Y-axis vel. data in mm/s (+ = Bm4 Bm3 xdcr movement relative to water mass) ±ZZZZZ = Z-axis vel. data in mm/s (+ = transducer movement away from water mass) ±EEEEE = Error velocity data in mm/s S = Status of velocity data (A = good, V = bad)
5	**WATER-MASS, SHIP-REFERENCED VELOCITY DATA** **:WS,±TTTTT,±LLLLL,±NNNNN,S <CR><LF>** where: ±TTTTT = Transverse vel. data in mm/s (+ = Port Stbd ship movement rel. to water mass) ±LLLLL = Longitudinal vel. data in mm/s (+ = Aft Fwd ship movement rel. to water mass) ±NNNNN = Normal velocity data in mm/s (+ = ship movement away from water mass) S = Status of velocity data (A = good, V = bad)

Continued Next Page

Table 59: DVL Output Data Format (PD13) (continued)

Line	Description
6	**WATER-MASS, EARTH-REFERENCED VELOCITY DATA** **:WE,±EEEEE,±NNNNN,±UUUUU,S <CR><LF>** where: ±EEEEE = East (u-axis) velocity data in mm/s (+ = DVL movement to east) ±NNNNN = North (v-axis) velocity data in mm/s (+ = DVL movement to north) ±UUUUU = Upward (w-axis) velocity data in mm/s (+ = DVL movement to surface) S = Status of velocity data (A = good, V = bad)
7	**WATER-MASS, EARTH-REFERENCED DISTANCE DATA** **:WD,±EEEEEEEE.EE,±NNNNNNNN.NN,±UUUUUUUU.UU,DDDD.DD,TTT.TT <CR><LF>** where: +EEEEEEEE.EE = East (u-axis) distance data in meters +NNNNNNNN.NN = North (v-axis) distance data in meters +UUUUUUUU.UU = Upward (w-axis) distance data in meters DDDD.DD = Range to water-mass center in meters TTT.TT = Time since last good-velocity estimate in seconds
8	**BOTTOM-TRACK, INSTRUMENT-REFERENCED VELOCITY DATA** **:BI,±XXXXX,±YYYYY,±ZZZZZ,±EEEEE,S <CR><LF>** where: ±XXXXX = X-axis velocity data in mm/s (+ = Bm1 Bm2 xdcr movement relative to bottom) ±YYYYY = Y-axis velocity data in mm/s (+ = Bm4 Bm3 xdcr movement relative to bottom) ±ZZZZZ = Z-axis velocity data in mm/s (+ = transducer movement away from bottom) ±EEEEE = Error velocity data in mm/s S = Status of velocity data (A = good, V = bad)
9	**BOTTOM-TRACK, SHIP-REFERENCED VELOCITY DATA** **:BS,±TTTTT,±LLLLL,±NNNNN,S <CR><LF>** where: ±TTTTT = Transverse vel. data in mm/s (+ = Port Stbd ship movement relative to bottom) ±LLLLL = Longitudinal vel. data in mm/s (+ = Aft Fwd ship movement relative to bottom) ±NNNNN = Normal velocity data in mm/s (+ = ship movement away from bottom) S = Status of velocity data (A = good, V = bad)
10	**BOTTOM-TRACK, EARTH-REFERENCED VELOCITY DATA** **:BE,±EEEEE,±NNNNN,±UUUUU,S <CR><LF>** where: ±EEEEE = East (u-axis) velocity data in mm/s (+ = DVL movement to east) ±NNNNN = North (v-axis) velocity data in mm/s (+ = DVL movement to north) ±UUUUU = Upward (w-axis) velocity data in mm/s (+ = DVL movement to surface) S = Status of velocity data (A = good, V = bad)
11	**BOTTOM-TRACK, EARTH-REFERENCED DISTANCE DATA** **:BD,±EEEEEEEE.EE,±NNNNNNNN.NN,±UUUUUUUU.UU,DDDD.DD,TTT.TT <CR><LF>** where: +EEEEEEEE.EE = East (u-axis) distance data in meters +NNNNNNNN.NN = North (v-axis) distance data in meters +UUUUUUUU.UU = Upward (w-axis) distance data in meters DDDD.DD = Range to bottom in meters TTT.TT = Time since last good-velocity estimate in seconds

15 How to Decode a DVL Ensemble

Use the following information to help you write your own software.

15.1 Rules for the BroadBand Data Format PD0

a. All data types (i.e. fixed leader, variable leader, velocity, echo intensity, correlation, percent good, etc.) will be given a specific and unique ID number. The table below shows some of the most common IDs.

Table 60: Common Data Format IDs

ID	Description
0x7F7F	Header
0x0000	Fixed Leader
0x0080	Variable Leader
0x0100	Velocity Profile Data
0x0200	Correlation Profile Data
0x0300	Echo Intensity Profile Data
0x0400	Percent Good Profile Data
0x0500	Status Profile Data
0x0600	Bottom Track Data
0x0800	MicroCAT Data

b. Once a data type has been given an ID number and the format of that data has been published we consider the format for each field has being fixed. Fixed refers to units used for a given field, the number of bytes in a given field, and the order in which the fields appear within the data type. Fixed does not refer to the total number of bytes in the data type - see Rule “c”.

c. Data may be added to an existing data type only by adding the bytes to the end of the data format. As an example, the variable leader data contains information on ensemble number, time, heading, pitch, roll, temperature, pressure, etc. The format for the bytes 1-53 are now specified by changes added in support to the Navigator DVL. If additional sensor data is to be added to the variable leader data then it must be added to the end of the data string (bytes 54-x as an example).

d. The order of data types in an ensemble is not fixed. That is there is no guarantee that velocity data will always be output before correlation data.

e. The header data will include the number of data types in the files and the offset to each ID number for each data type.

f. The total number of the bytes in an ensemble minus the 2-byte checksum will be included in the header.

15.2 Recommended Data Decoding Sequence for BroadBand Data Format PD0

a. Locate the header data by locating the header ID number (in the case of PD0 profile data that will be 7F7F).

b. Confirm that you have the correct header ID by:

1. Locating the total number of bytes (located in the header data) in the ensemble. This will be your offset to the next ensemble.
2. Calculate the checksum of total number of bytes in the ensemble excluding the checksum. The checksum is calculated by adding the value of each byte. The 2-byte least significant digits that you calculate will be the checksum.
3. Read the 2-byte checksum word at the end of the ensemble, located by using the checksum offset in the header (determined in step "b-1") and compare this checksum word to the value calculated in step "b-2".
4. If the checksums match then you have a valid ensemble. If the checksums do not match then you do not have a valid ensemble and you need to go back to step "a" and search for the next header ID number occurrence.

c. Locate the number of data types (located in the header data).

d. Locate the offset to each data type (located in the header data).

e. Locate the data ID type you wish to decode by using the offset to each data type and confirm the data ID number at that offset matches the ID type you are looking for.

f. Once the proper ID type has been located, use the DVL Technical Manual for the DVL you are using to understand what each byte represents in that particular data type.

15.3 Pseudo-Code for Decoding PD0 Ensemble Data

The following examples show the pseudo-code for decoding PD0 and PD5 ensemble data.

g. Define structures, which contain all fields in all data types of the PD0 format.

1. typedef struct { <lists of types and fields> } FixedLeader.
2. typedef struct { <lists of types and fields> } VariableLeader.

   3. typedef struct { <lists of types and fields> } BottomTrack.
   4. typedef struct { <lists of types and fields> } VelocityType
   5. and so on for every available type.

h. Clear checksum.

i. Look for PD0 ID 0x7F. Add to checksum.

j. Is next byte a 0x7F? Add to checksum.

k. If no, return to step “b”.

l. Else, read next two bytes to determine offset to checksum. Add two bytes to checksum.

m. Read in X more bytes, where X = offset to checksum - 4. Adding all bytes to checksum.

n. Read in checksum word.

o. Do checksums equal?

p. If no, return to “b”.

q. For each available data type (the header contains the # of data types), go to the offset list in header.

   1. Create a pointer to type short to the data type at an offset in the list.
   2. Check the Type ID.
   3. Create a pointer of appropriate type to that location.
   4. Repeat for all available data types.

r. Work with data.

s. Return to “b” for next ensemble.

15.4 Pseudo-Code for Decoding PD5 Ensemble Data

a. Define structure that contains all fields in PD5 format.

   1. typedef struct { <lists of types and fields> } PD5_Format.

b. Clear checksum.

c. Look for ID, PD5 id is 0x7D. Add to checksum.

d. Is next byte a 0x01? Add to checksum.

e. If no, return to “b”.

f. Else, read next two bytes to determine offset to checksum. Add two bytes to checksum.

g. Read in X more bytes, where X = offset to checksum - 4. Adding all bytes to checksum.

h. Read in checksum word.

i. Do checksums equal?

j. If no, return to “b”.

k. Create a pointer of type PD5_Format.

   1. PD5_Format *PD5_ptr;

l. Point pointer at location of ID byte.

   1. PD5_ptr = &buf[<location of input buffer>];

m. If “k” and “l” don't appeal to you, you can create a variable of type PD5_Format.

   1. PD5_Format PD5_data;

n. And copy the data from the input buffer to PD5_data.

o. Work with data.

p. Return to “b” for next ensemble.

15.5 Example Code for Decoding BroadBand Ensembles

Here is an example of how to decode a BroadBand ensemble. It is written in “C.”

NOTE. Structures must be “packed”; i.e. Don’t let the compiler add “fill bytes” to align fields on word boundaries.

This is an example of a section of code, not a full executable program.

```
/***************************************************************************/
/* Data ID Words */
/***************************************************************************/

   #define FLdrSelected   0x0000
   #define VLdrSelected   0x0080
   #define VelSelected    0x0100
   #define CorSelected    0x0200
   #define AmpSelected    0x0300
   #define PctSelected    0x0400
   #define SttSelected    0x0500
   #define BotSelected    0x0600
   #define Prm0           0x0700

   #define VelGood        0x0701
   #define VelSum         0x0702
   #define VelSumSqr      0x0703
   #define Bm5VelSelected 0x0A00
   #define Bm5CorSelected 0x0B00
   #define Bm5AmpSelected 0x0C00
   #define AmbientData    0x0C02
   #define Bm5PctSelected 0x0D00
   #define Bm5SttSelected 0x0E00
   #define Prm0_5         0x1300
```

```
   #define VelGood_5      0x1301
   #define VelSum_5       0x1302
   #define VelSumSqr_5    0x1303

/*************************************************************************/
/* structures */
/*************************************************************************/

   typedef unsigned char  uchar;
   typedef unsigned short ushort;
   typedef unsigned long  ulong;

   typedef struct {
      uchar        Minute,
                   Second,
                   Sec100;
   }  TimeType;

   typedef struct {
      uchar        Year,
                   Month,
                   Day,
                   Hour,
                   Minute,
                   Second,
                   Sec100;
   }  DateTimeType;

   typedef struct {
      uchar        Version,
                   Revision;
   }  VersionType;

   typedef struct {
      uchar        ID,
                   DataSource;
      ushort       ChecksumOffset;
      uchar        Spare,
                   NDataTypes;
      ushort       Offset [256];
   }  HeaderType;

   typedef struct {
      ushort       ID;
      VersionType  CPUFirmware;
      ushort       Configuration;
      uchar        DummyDataFlag,
                   Lag,
                   NBeams,
                   NBins;
      ushort       PingsPerEnsemble,
                   BinLength,
                   BlankAfterTransmit;
      uchar        ProfilingMode,
                   PctCorrelationLow,
                   NCodeRepetitions,
                   PctGoodMin;
      ushort       ErrVelocityMax;
      TimeType     TimeBetweenPings;
      uchar        CoordSystemParms;
      short        HeadingAlignment,
                   HeadingBias;
      uchar        SensorSource,
                   AvailableSensors;
      ushort       DistanceToBin1Middle,
                   TransmitLength;
   }  FixLeaderType;

   typedef struct {
      ushort       ID,
                   EnsembleNumber;

      DateTimeType RecordingTime;
      uchar        Spare1;
      ushort       BITResult,
                   SpeedOfSound,
                   Depth,
                   Heading;
```

```
   short        Pitch,
                Roll;
   ushort       Salinity;
   short        Temperature;
   TimeType     MaxTimeBetweenPings;
   uchar        HeadingStddev,
                PitchStddev,
                RollStddev;
   uchar        VMeas [8];
}  VarLeaderType;

typedef struct {
   ushort       ID,
                PingsPerEnsemble,
                EnsembleDelay;
   uchar        CorrelationMin,
                AmplitudeMin,
                PctGoodMin,
                BTMode;
   ushort       ErrVelocityMax,
                NSearchPings,
                NTrackPings;
   ushort       Range        [4];
   short        Velocity     [4];
   uchar        Correlation  [4],
                Amplitude    [4],
                PctGood      [4];
   ushort       WaterLayerMin,
                WaterLayerNear,
                WaterLayerFar;
   short        WVelocity    [4];
   uchar        WCorrelation [4],
                WAmplitude   [4],
                WPctGood     [4];
   ushort       MaxTrackingDepth;
   uchar        Amp [4];
   uchar        Gain;
   uchar        RangeMSB [4];
}  BottomTrackType;

typedef struct
{
  ushort        ID;
  short         Data [256];
} OneBeamShortType;

typedef struct
{
  ushort        ID;
  uchar         Data [256];
} OneBeamUcharType;

typedef struct {
   ushort       ID;
   short        Data [1024];
}  IntStructType;

typedef struct {
   ushort       ID;
   uchar        Data [1024];
}  ByteStructType;

typedef struct
{
  ushort        ID;
  uchar         Data [4];
}  AmbientType;

typedef struct
{
  ushort        ID;
  ushort        UaH;
  ushort        UaL;
  ushort        AmbBitsPerBin;
  ushort        AmbTrys;
  ushort        AmbNBins;
  short         AmbBinNum [ 5 ];
  short         Est [ 5 ];
```

```
      ushort        WAutoCor [ 5 ] [ 32 ];
      uchar         SysFreq;
      uchar         SampRate;
    }  T01Type;

    typedef struct
    {
      ushort        ID;
      uchar         DAC [36];
    }  T02Type;

    typedef struct
    {
      ushort        ID;
      ushort        RSSIBinLen;
      ushort        RSSIBins;
      uchar         RSSI [512] [4];
      ushort        AutoCor [32] [4];
      short         Est [4];
      ushort        Amb [4];
      uchar         SysFreq;
      uchar         SampRate;
      uchar         MLen;
      ushort        XmtSamples;
      ushort        FirstBin[4];
      ushort        LastBin[4];
      ulong         BM6Depth[4];
      ushort        BM6Ta[4];
    }  T03Type;

/*****************************************************************************/
/* Global Pointers */
/*****************************************************************************/
    HeaderType       *HdrPtr;
    FixLeaderType    *FLdrPtr;
    VarLeaderType    *VLdrPtr;
    BottomTrackType  *BotPtr;
    BottomTrackType  *WBotPtr;
    IntStructType    *VelPtr;
    ByteStructType   *CorPtr;
    ByteStructType   *AmpPtr;
    ByteStructType   *PctPtr;
    ByteStructType   *SttPtr;
    AmbientType      *AmbientPtr;
    T01Type          *T01Ptr;
    T02Type          *T02Ptr;
    T03Type          *T03Ptr;
    OneBeamShortType *Bm5VelPtr;
    OneBeamUcharType *Bm5CorPtr;
    OneBeamUcharType *Bm5AmpPtr;
    OneBeamUcharType *Bm5PctPtr;
    OneBeamUcharType *Bm5SttPtr;

/*---------------------------------------------------------------------------*/

unsigned char RcvBuff[8192];


void DecodeBBensemble( void )
{
    unsigned short i, *IDptr, ID;

    FLdrPtr = (FixLeaderType *)&RcvBuff [ HdrPtr->Offset[0] ];

    if (FLdrPtr->NBins > 128)
        FLdrPtr->NBins = 32;

    for (i=1; i<HdrPtr->NDataTypes; i++)
    {
        IDptr = (unsigned short *)&RcvBuff [ HdrPtr->Offset [i] ];
        ID = IDptr[0];

        switch (ID)
        {
        case VLdrSelected:
            {
                VLdrPtr = (VarLeaderType *)&RcvBuff [ HdrPtr->Offset [i] ];
                break;
```

```
                }
            case VelSelected:
                {
                    VelPtr = (IntStructType *)&RcvBuff [ HdrPtr->Offset [i] ];
                    break;
                }
            case CorSelected :
                {
                    CorPtr = (ByteStructType *)&RcvBuff [ HdrPtr->Offset [i] ];
                    break;
                }
            case AmpSelected :
                {
                    AmpPtr = (ByteStructType *)&RcvBuff [ HdrPtr->Offset [i] ];
                    break;
                }
            case PctSelected :
                {
                    PctPtr = (ByteStructType *)&RcvBuff [ HdrPtr->Offset [i] ];
                    break;
                }
            case SttSelected :
                {
                    SttPtr = (ByteStructType *)&RcvBuff [ HdrPtr->Offset [i] ];
                    break;
                }
            case BotSelected :
                {
                    BotPtr = (BottomTrackType*)&RcvBuff [ HdrPtr->Offset [i] ];
                    break;
                }
            case AmbientData :
                {
                    AmbientPtr = (AmbientType *)&RcvBuff [ HdrPtr->Offset [i] ];
                    break;
                }
            }
        }
    }
```

16 Specifications

A brief review of DVL operation may help you understand the specifications listed in this section.

> **NOTE.** The specifications and dimensions listed in this section are subject to change without notice.

The DVL emits an acoustic pulse called a PING. Scatterers that float ambiently with the water currents reflect some of the energy from the ping back to the DVL. The DVL uses the return signal to calculate a velocity. The energy in this signal is the *echo intensity*. Echo intensity is sometimes used to determine information about the scatterers.

The velocity calculated from each ping has a *statistical uncertainty*; however, each ping is an independent sample. The DVL reduces this statistical uncertainty by averaging a collection of pings. A collection of pings averaged together is an *ensemble*. The DVL's maximum *ping rate* limits the time required to reduce the statistical uncertainty to acceptable levels.

The DVL does not measure velocity at a single point; it measures velocities throughout the water column. The DVL measures velocities from its transducer head to a specified range and divides this range into uniform segments called *depth cells* (or *bins*). The collection of depth cells yields a *profile*. The DVL produces two profiles, one for velocity, and one for echo intensity.

The DVL calculates velocity data relative to the DVL. The velocity data has both speed and direction information. If the DVL is moving, and is within range of the bottom, it can obtain a velocity from returns off the bottom. This is called *bottom tracking.* The bottom track information can be used to calculate the absolute velocity of the water. The DVL can get absolute direction information from a heading sensor.

The following tables list the specifications for the WorkHorse DVL. About the specifications:

a. All these specifications assume minimal DVL motion - pitch, roll, heave, rotation, and translation.

b. Except where noted, this specification table applies to typical setups and conditions. Typical setups use the default input values for each parameter (exceptions include Pings Per Ensemble and Number of Depth Cells). Typical conditions assume uniform seawater velocities at a given depth, moderate shear, moderate DVL motion, and typical echo intensity levels.

c. The total measurement error of the DVL is the sum of:

    - Long-term instrument error (as limited by instrument accuracy).
    - The remaining statistical uncertainty after averaging.
    - Errors introduced by measurement of DVL heading and motion.

d. Because individual pings are independent, the statistical uncertainty of the measurement can be reduced according to the equation:

$$\frac{\text{Statistical Uncertainty for One Ping}}{\sqrt{\text{Number of Pings}}}$$

Table 61: Navigator Altitude (Uncertainty±1%)

System Frequency	1200kHz	600kHz	300kHz
Maximum Altitude (m)	30	90	200
Minimum Altitude (m)	0.5	0.7	1.0

Table 62: Navigator Bottom Velocity (for |V| < 10 m/s)

Precision (cm/s)*	1200 kHz	600 kHz	300 kHz
V=1.0 m/s	0.3	0.3	0.3
V=3.0 m/s	0.4	0.5	0.6
V=5.0 m/s	0.5	0.6	0.8
Accuracy (cm/s)	±0.2% ±0.2	±0.3% ±0.2	±0.4% ± 0.4
Maximum Ping Rate**	1 to 10 Hz	0.5 to 7 Hz	0.5 to 7 Hz

* Water and Bottom velocity precision are standard deviations of horizontal velocities for single pings. The standard deviation for an ensemble of pings will decrease proportional to the square root of the number of pings averaged together.

* Single Ping Precision calculated for an altitude of one-half maximum altitude for a given frequency.

** Ping rates vary due to altitude, baud rate, and amount of water profiled.

Table 63: Navigator Water Velocity (Reference Layer*)

Range limits(m)		1200 kHz	300 kHz
	Minimum	0.25	1.0
	Maximum	18	110
Short-term error: Precision (cm/s)**			
	Ref. Layer Size=1.0 m	6	15
	Ref. Layer Size=2.0 m	5	9
	Ref. Layer Size=4.0 m	3	6
	Ref. Layer Size=8.0 m	2	5
Long-term Error: Accuracy (cm/s)		±0.2% ±0.1	±0.4% ±0.2
Ping Rate***		1 to 10 Hz	0.5 to 7 Hz

* Reference layer maximum ranges are for typical water conditions: 35% salinity, 10°C temperature.

** Water and Bottom velocity precision are standard deviations of horizontal velocities for single pings. The standard deviation for an ensemble of pings will decrease proportional to the square root of the number of pings averaged together.

** Single Ping Precision calculated for an altitude of one-half maximum altitude for a given frequency.

*** Ping rates vary due to altitude, baud rate, and amount of water profiled.

Table 64: Echo Intensity Profile

Vertical resolution	Depth cell size
Dynamic range	80 dB
Precision	± 1.5dB (relative measure)

Table 65: Navigator Water Profiling

Depth Cell Size[1]	Nominal range 15m[2] 1200kHz		Nominal range 55m[2] 600kHz		Nominal range 135m[2] 300kHz	
Vertical Resolution	Range[3] (m)	Std. dev.[4] (mm/s)	Range[3] (m)	Std. dev.[4] (mm/s)	Range[3] (m)	Std. dev.[4] (mm/s)
0.25m	12	182				
0.50m	13	66	40	182		
1.0m	15	30	45	66	97	182
2.0m	16	18	50	30	110	66
4.0m			56	18	123	30
8.0m					138	18

NOTES

1. User's choice of depth cell size is not limited to the typical values specified.
2. Longer ranges are available.
3. Range, which depends on cell size, is specified here for BroadBand mode at 5° C, typical ocean backscatter, and nominal 48 VDC power.
4. Broad bandwidth mode single-ping standard deviation

NOTE. Water Profiling is an upgrade feature for the Navigator.

Table 66: Long Range Mode

	Range (m) @ 33VDC	Range (m) @ 48VDC	Depth Cell Size (m)	Std. dev. (mm/s)
1200kHz	19	20	2	35
600kHz	67	70	4	38
300kHz	165	175	8	38

Range, which depends on cell size, is specified here for narrow bandwidth mode at 5° C, typical ocean backscatter, and nominal 33 VDC (optional external battery pack) or 48VDC input power (power supply).

Table 67: Standard Sensors

Temperature (mounted on transducer)

Range: -5° to 45° C

Precision: ± 0.4° C

Resolution: 0.01°

Tilt

Range: ± 15°

Accuracy: ± 0.5°

Precision: ± 0.5°

Resolution: 0.01°

Compass (fluxgate type, includes built-in field calibration feature)

Accuracy: ± 2°[1]

Precision: ± 0.50[1]

Resolution: 0.01°

Maximum tilt: ± 15°

Note: 1) @ 60° magnetic dip angle, 0.5G total field

Table 68: Transducer and Hardware

	1200kHz	300kHz	600kHz
Available Frequency	1,228,800 actual	307,200 actual	614,400 actual
Beamwidth	1.2°	3.9°	2.0°
Beam Angle	30°		
Configuration	4-beam, convex		
Housing & Transducer material	6061 or 7075 Aluminum or Titanium		
External connector	7-pin low-profile		
Internal memory	Memory card not included with Navigator models. Two PCMCIA memory card slots are available, with the total memory capacity not to exceed 2GB.		
Communications	Serial port selectable by switch for RS-232 or RS-422. ASCII or binary output at 1200 to 115,400 baud.		

Table 69: Environmental

Standard depth rating	3000m (6000-meter housings available)
Operating temperature with or without batteries	-5° to 45°C
Short Term Storage/Shipping (<45days) temperature (Batteries Installed in External Battery Case)	-5° to 45°C
Long Term Storage (>45days) temperature (Batteries Installed in External Battery Case)	O° C to 21° C
Long Term Storage (>45days) temperature (Batteries Removed from External Battery Case)	-30° to 60°C
Long Term (>45days) Battery Storage	Batteries should be stored in cool dry air with a temperature range of O° C to 21° C.
Battery Shelf Life	Use within one year.

CAUTION. Batteries stored for more than 12 months should NEVER be used!

NOTE. Batteries less than 12 months old may be used for any length deployment. For example, if your deployment is going to be 12 months long and the battery label shows it is nine months old, it is safe to use the battery.

Table 70: Power

System	Specification
DC input	20 to 50 VDC external power supply
External Battery Pack	42 VDC (new), 28 VDC (depleted). Holds up to two 450 watt hour batteries
Transmit	16W @ 35V (1200kHz), 37W @ 35V (600kHz), 115W @ 35V (300kHz) 22W @ 48V (1200kHz), 60W @ 48V (600kHz), 190W @ 48V (300kHz)

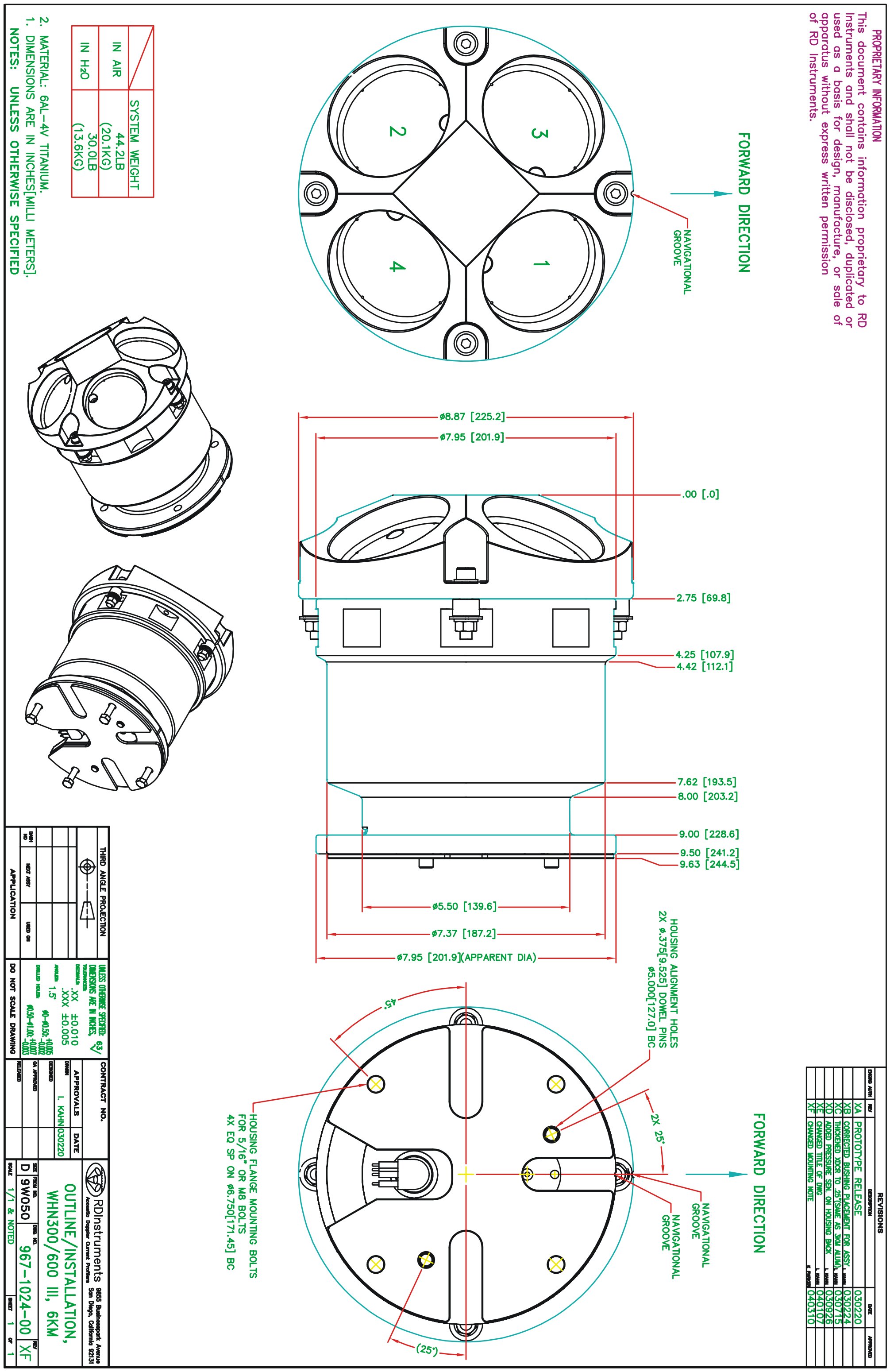
17 Outline Installation Drawings

The following drawings show the Navigator DVL dimensions and weights.

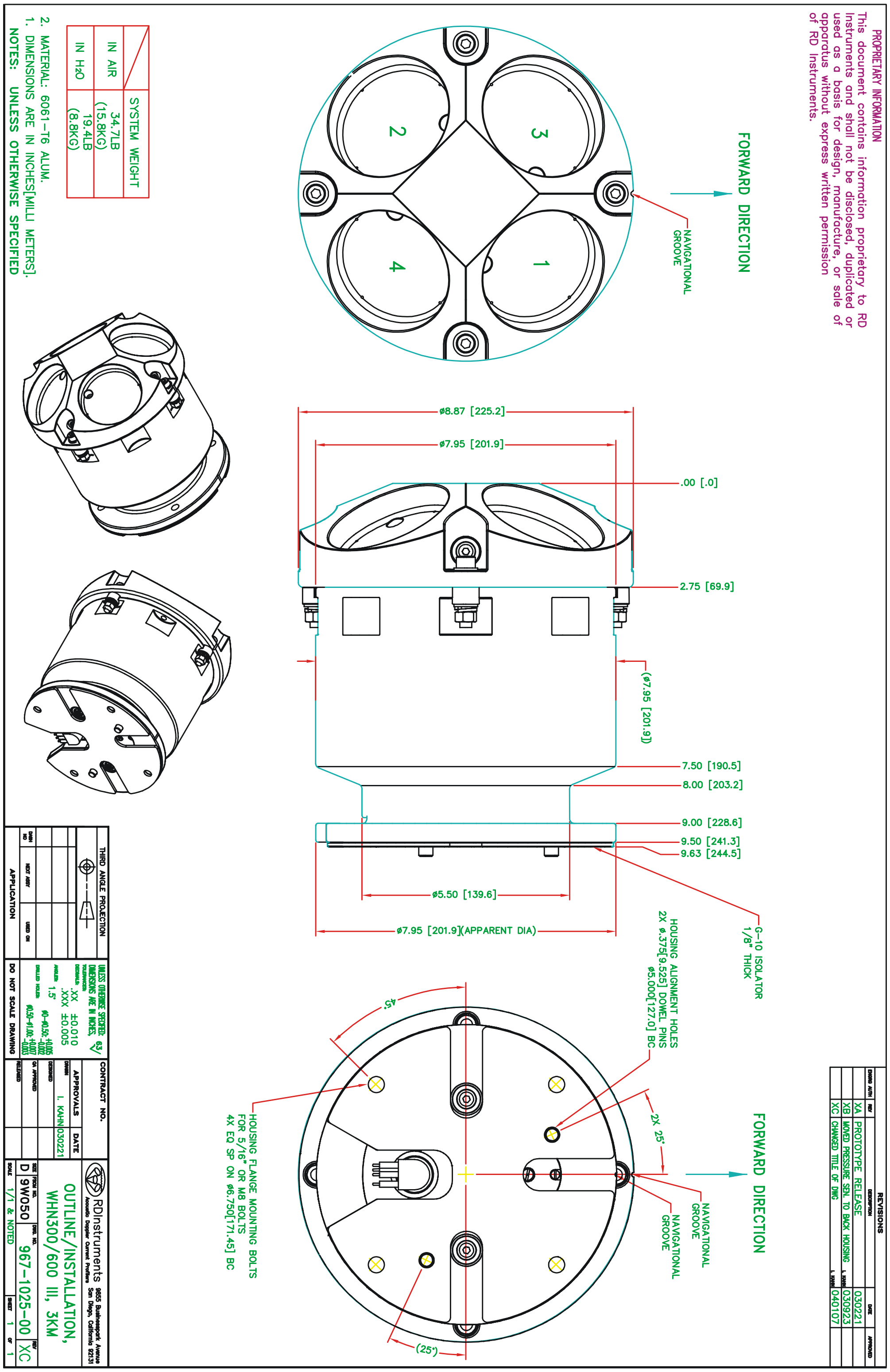
Table 71: Outline Installation Drawings

Description	Drawing #
300/600kHz Navigator III, 6000 meter	967-1024 Rev. XF
300/600kHz Navigator III, 3000 meter	967-1025 Rev. XC
1200kHz Navigator III, 3000 meter	967-1026 Rev. XD
1200kHz Navigator III, 6000 meter	967-1027 Rev. XC
External Battery Case, 6000 meter	967-4001 Rev. XE

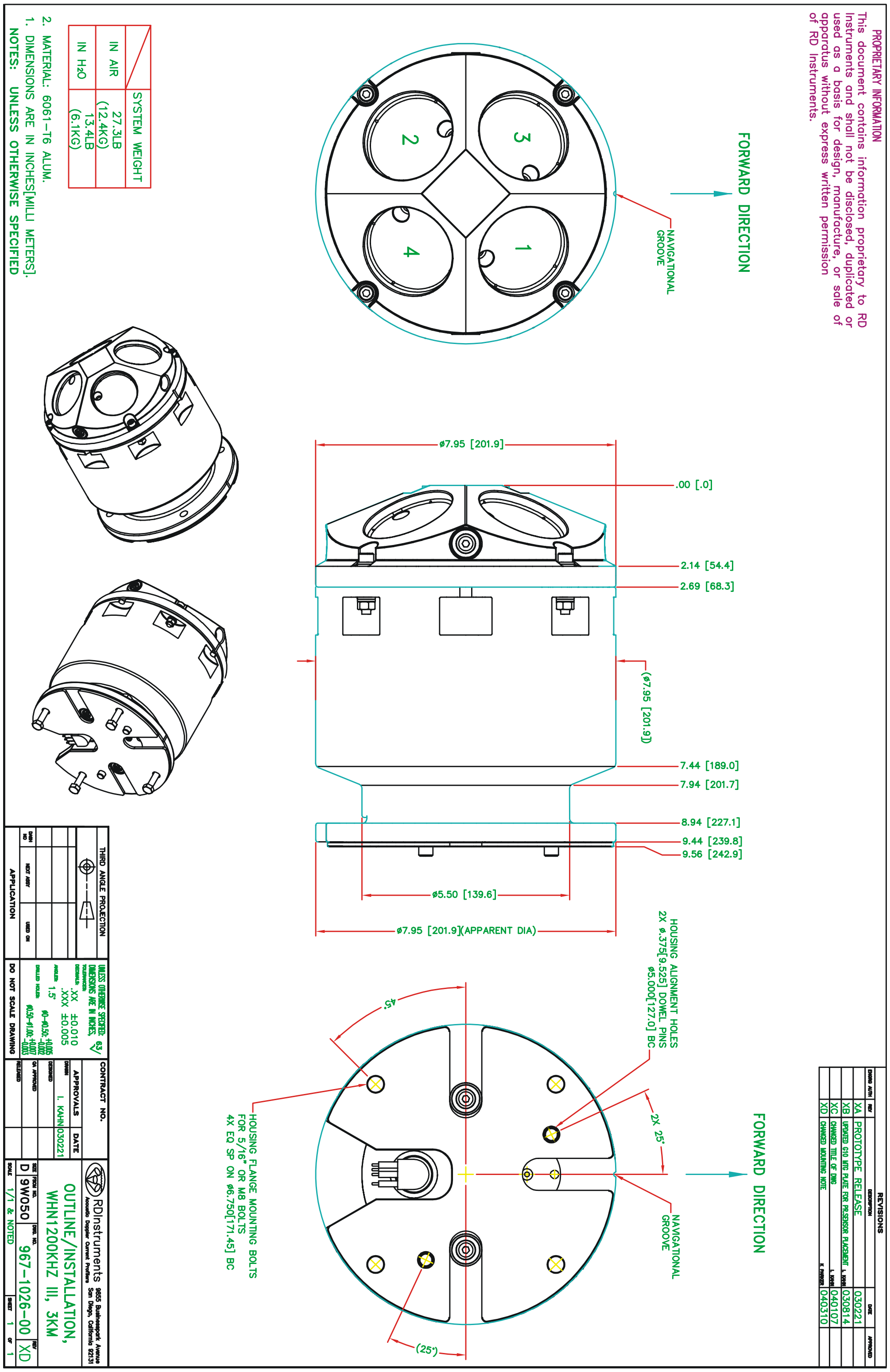
967-1024


PROPRIETARY INFORMATION
This document contains information proprietary to RD Instruments and shall not be disclosed, duplicated or used as a basis for design, manufacture, or sale of apparatus without express written permission of RD Instruments.
FORWARD DIRECTION
NAVIGATIONAL GROOVE
1
2
3
4
SYSTEM WEIGHT
IN AIR 44.2LB (20.1KG)
IN H2O 30.0LB (13.6KG)
NOTES: UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS ARE IN INCHES[MILLI METERS].
2. MATERIAL: 6AL-4V TITANIUM.
ø8.87 [225.2]
ø7.95 [201.9]
.00 [.0]
2.75 [69.8]
4.25 [107.9]
4.42 [112.1]
7.62 [193.5]
8.00 [203.2]
9.00 [228.6]
9.50 [241.2]
9.63 [244.5]
ø5.50 [139.6]
ø7.37 [187.2]
ø7.95 [201.9](APPARENT DIA)
HOUSING ALIGNMENT HOLES
2X ø.375[9.525] DOWEL PINS
ø5.000[127.0] BC
HOUSING FLANGE MOUNTING BOLTS
FOR 5/16" OR M8 BOLTS
4X EQ SP ON ø6.750[171.45] BC
2X 25°
45°
(25°)
THIRD ANGLE PROJECTION
APPLICATION
DO NOT SCALE DRAWING
CONTRACT NO.
APPROVALS
DATE
L. KAHN 030220
RDInstruments
OUTLINE/INSTALLATION,
WHN300/600 III, 6KM
D 9W050
967-1024-00
XF
1/1 & NOTED
SHEET 1 OF 1
REVISIONS
XA PROTOTYPE RELEASE 030220

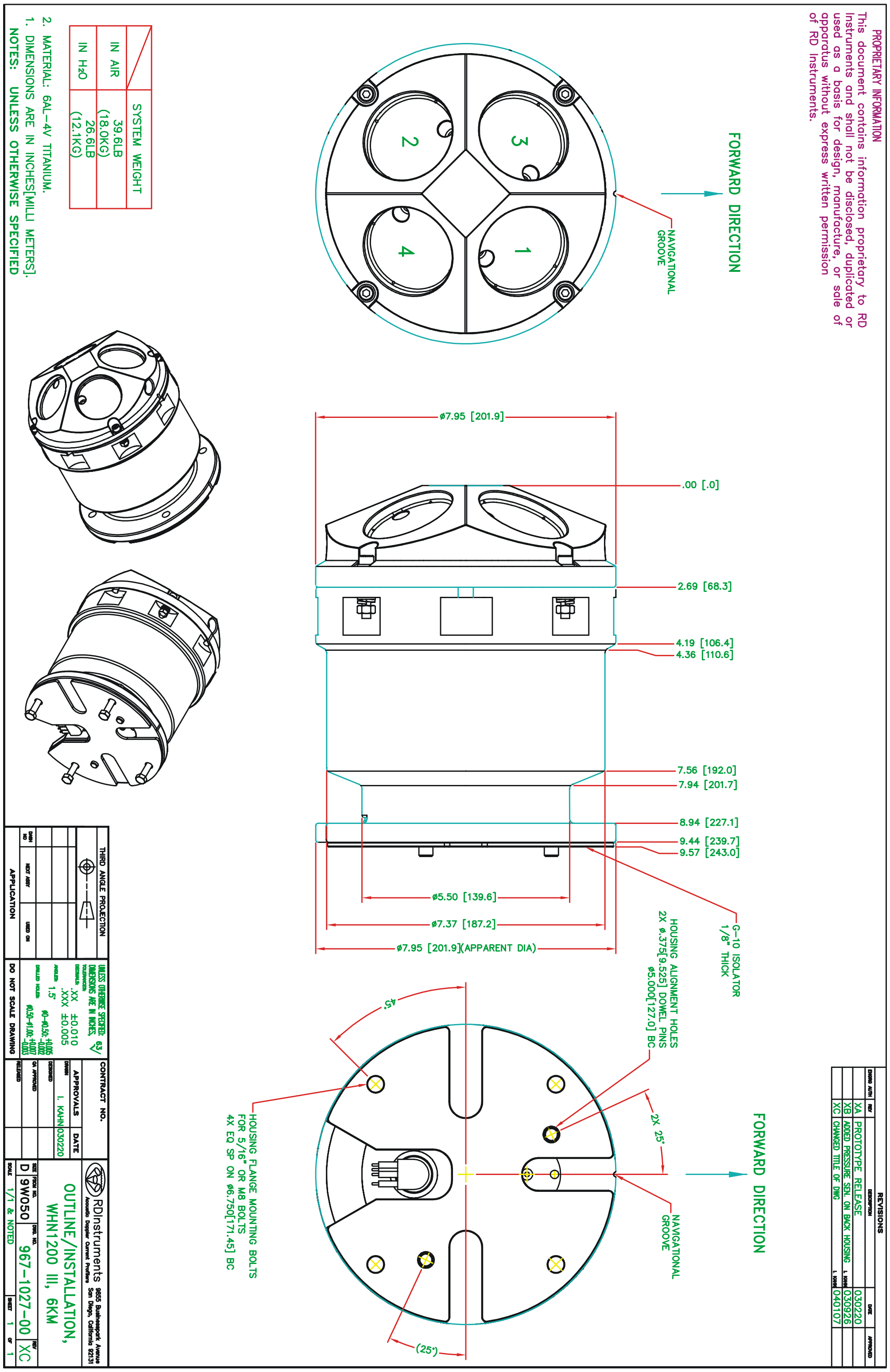
967-1025


PROPRIETARY INFORMATION
This document contains information proprietary to RD Instruments and shall not be disclosed, duplicated or used as a basis for design, manufacture, or sale of apparatus without express written permission of RD Instruments.
FORWARD DIRECTION
NAVIGATIONAL GROOVE
3
2
1
4
SYSTEM WEIGHT
IN AIR 34.7LB (15.8KG)
IN H2O 19.4LB (8.8KG)
NOTES: UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS ARE IN INCHES[MILLI METERS].
2. MATERIAL: 6061-T6 ALUM.
ø8.87 [225.2]
ø7.95 [201.9]
.00 [.0]
2.75 [69.9]
(ø7.95 [201.9])
7.50 [190.5]
8.00 [203.2]
9.00 [228.6]
9.50 [241.3]
9.63 [244.5]
ø5.50 [139.6]
ø7.95 [201.9](APPARENT DIA)
G-10 ISOLATOR 1/8" THICK
HOUSING ALIGNMENT HOLES 2X ø.375[9.525] DOWEL PINS ø5.000[127.0] BC
HOUSING FLANGE MOUNTING BOLTS FOR 5/16" OR M8 BOLTS 4X EQ SP ON ø6.750[171.45] BC
45°
2X 25°
(25°)
REVISIONS
XA PROTOTYPE RELEASE 030221
XB MOVED PRESSURE SEAL TO BACK HOUSING 030923
XC CHANGED TITLE OF DWG 040107
THIRD ANGLE PROJECTION
APPLICATION
.XX ±0.010
.XXX ±0.005
1.5°
DO NOT SCALE DRAWING
CONTRACT NO.
APPROVALS DATE
L. KAHN 030221
RDInstruments
OUTLINE/INSTALLATION, WHN300/600 III, 3KM
D 9W050 967-1025-00 XC
1/1 & NOTED
SHEET 1 OF 1

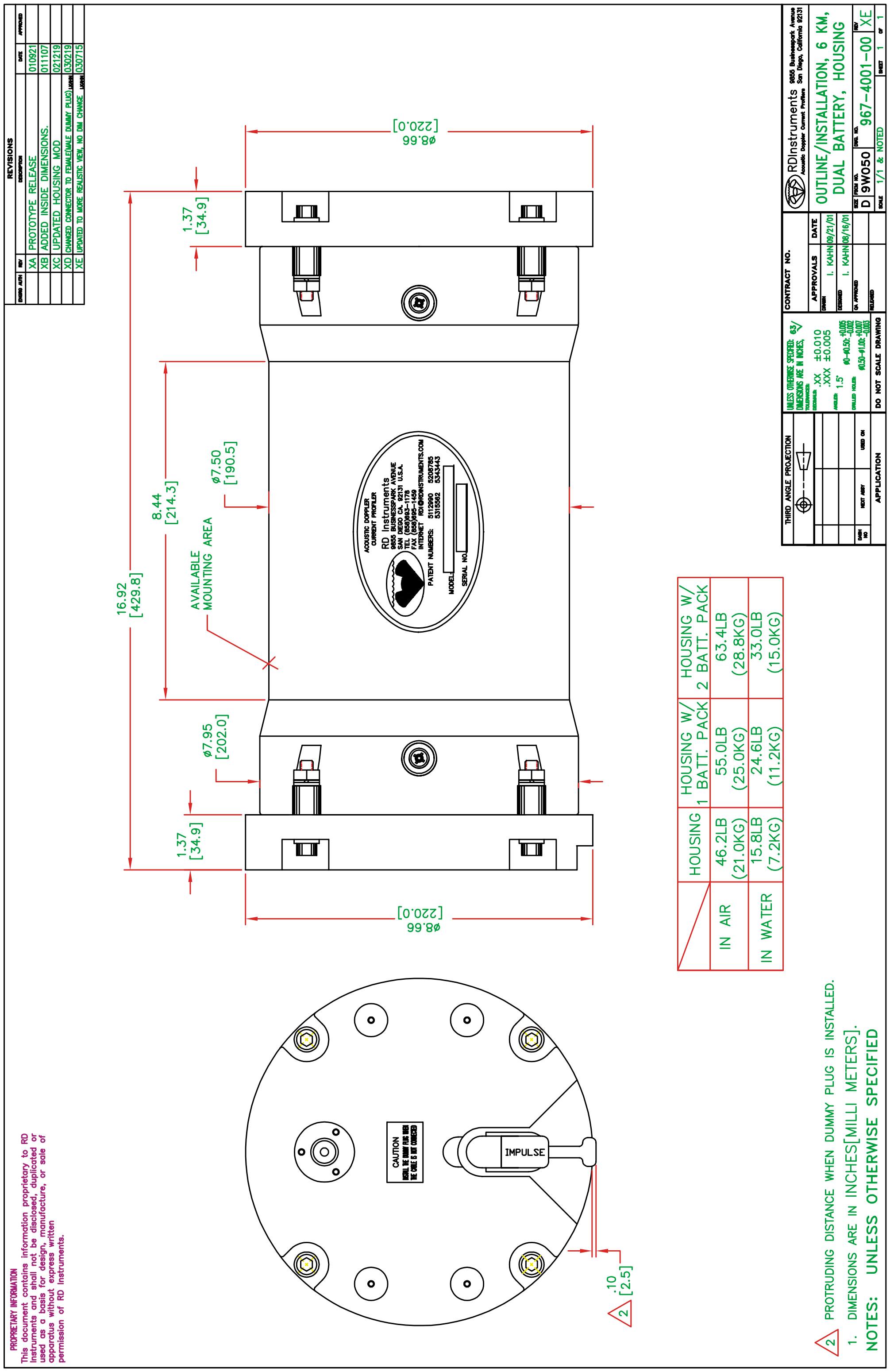
967-1026


PROPRIETARY INFORMATION
This document contains information proprietary to RD Instruments and shall not be disclosed, duplicated or used as a basis for design, manufacture, or sale of apparatus without express written permission of RD Instruments.
FORWARD DIRECTION
NAVIGATIONAL GROOVE
1
2
3
4
ø7.95 [201.9]
.00 [.0]
2.14 [54.4]
2.69 [68.3]
(ø7.95 [201.9])
7.44 [189.0]
7.94 [201.7]
8.94 [227.1]
9.44 [239.8]
9.56 [242.9]
ø5.50 [139.6]
ø7.95 [201.9](APPARENT DIA)
HOUSING ALIGNMENT HOLES
2X ø.375[9.525] DOWEL PINS
ø5.000[127.0] BC
2X 25°
45°
(25°)
HOUSING FLANGE MOUNTING BOLTS
FOR 5/16" OR M8 BOLTS
4X EQ SP ON ø6.750[171.45] BC
FORWARD DIRECTION
NAVIGATIONAL GROOVE
SYSTEM WEIGHT
IN AIR 27.3LB (12.4KG)
IN H2O 13.4LB (6.1KG)
NOTES: UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS ARE IN INCHES[MILLI METERS].
2. MATERIAL: 6061-T6 ALUM.
REVISIONS
XA PROTOTYPE RELEASE 030221
XB 030814
XC 040107
XD 040310
THIRD ANGLE PROJECTION
APPLICATION
DO NOT SCALE DRAWING
CONTRACT NO.
APPROVALS DATE
L. KAHN 030221
RDInstruments
OUTLINE/INSTALLATION,
WHN1200KHZ III, 3KM
D 9W050 967-1026-00 XD
1/1 & NOTED

967-1027


PROPRIETARY INFORMATION
This document contains information proprietary to RD Instruments and shall not be disclosed, duplicated or used as a basis for design, manufacture, or sale of apparatus without express written permission of RD Instruments.
FORWARD DIRECTION
NAVIGATIONAL GROOVE
SYSTEM WEIGHT
IN AIR 39.6LB (18.0KG)
IN H2O 26.6LB (12.1KG)
NOTES: UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS ARE IN INCHES[MILLI METERS].
2. MATERIAL: 6AL-4V TITANIUM.
ø7.95 [201.9]
.00 [.0]
2.69 [68.3]
4.19 [106.4]
4.36 [110.6]
7.56 [192.0]
7.94 [201.7]
8.94 [227.1]
9.44 [239.7]
9.57 [243.0]
ø5.50 [139.6]
ø7.37 [187.2]
ø7.95 [201.9](APPARENT DIA)
G-10 ISOLATOR 1/8" THICK
HOUSING ALIGNMENT HOLES 2X ø.375[9.525] DOWEL PINS ø5.000[127.0] BC
HOUSING FLANGE MOUNTING BOLTS FOR 5/16" OR M8 BOLTS 4X EQ SP ON ø6.750[171.45] BC
45°
2X 25°
(25°)
REVISIONS
XA PROTOTYPE RELEASE 030220
XB ADDED PRESSURE SEN. ON BACK HOUSING 030926
XC CHANGED TITLE OF DWG 040107
THIRD ANGLE PROJECTION
APPLICATION
DO NOT SCALE DRAWING
CONTRACT NO.
APPROVALS DATE
L. KAHN 030220
RDInstruments
OUTLINE/INSTALLATION, WHN1200 III, 6KM
D 9W050 967-1027-00 XC
SCALE 1/1 & NOTED SHEET 1 OF 1

967-4001


OUTLINE/INSTALLATION, 6 KM, DUAL BATTERY, HOUSING
967-4001-00
XE
9W050
RDInstruments
REVISIONS
XA PROTOTYPE RELEASE 010921
XB ADDED INSIDE DIMENSIONS. 011107
XC UPDATED HOUSING MOD. 021219
XD CHANGED CONNECTOR TO FEMALE(MALE DUMMY PLUG) 030219
XE UPDATED TO MORE REALISTIC VIEW, NO DIM CHANGE 030715
ø8.66 [220.0]
1.37 [34.9]
16.92 [429.8]
8.44 [214.3]
ø7.50 [190.5]
ø7.95 [202.0]
AVAILABLE MOUNTING AREA
.10 [2.5]
IMPULSE
HOUSING
HOUSING W/ 1 BATT. PACK
HOUSING W/ 2 BATT. PACK
IN AIR 46.2LB (21.0KG) 55.0LB (25.0KG) 63.4LB (28.8KG)
IN WATER 15.8LB (7.2KG) 24.6LB (11.2KG) 33.0LB (15.0KG)
NOTES: UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS ARE IN INCHES[MILLI METERS].
2 PROTRUDING DISTANCE WHEN DUMMY PLUG IS INSTALLED.
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING
1/1 & NOTED

18 Firmware History

```
-----------------------------------------------------------------
Version 9.00:  25JAN96 Baseline Navigator Firmware
-----------------------------------------------------------------
Version 9.01:  01MAR96 Special Customer FW (Dual xducer head)
-----------------------------------------------------------------
Version 9.02:  01MAR96
 -Fixed problem where the Far Water Layer parameter would be
  incorrectly saved and restored from non-volatile memory.
 -Added code for 1200-kHz systems.
 -Added field calibration routine of compass to eliminate hard
  iron errors (AF command).
 -Improved output of error estimating routine (AX command).
 -Improved diagnostics for loading calibration parameters.
 -Added RT command for ASCII file transfer to recorder (used by
  software to store deployment setup file on recorder).
 -Changed deployment numbering system. Numbering sequences are
  now independent for each deployment name used.
 -Requires new boot code version 1.8 wh.
 -Added capability to upgrade firmware when in RS-422 mode.
 -Added boot code version tracking. With this and later versions
  of firmware, the system will complain if wrong boot code
  version is used.
 -Added recorder Built-In Test (RB command).
 -Added battery saver mode (system sleeps if no input at command
  prompt for 5 minutes).
 -Improved equation coefficients for temperature sensor.
 -Fixed a 'recorder not present' error message in CF command.
 -Improved user interface for compass performance evaluation
  algorithm and compass field calibration algorithm.
 -Fixed file naming error in RT command.
 -Added AC command to log compass calibration parameters.
 -Fixed problem where error message would be output if WN command
  was set to a value that was less than the number of water
  reference layer bins (WL).
 -Fixed problem where system would wake up and beep forever with
  no communication.
 -Fixed problem where recorder would be incorrectly marked as
  being full if a file ended on certain sector boundaries.
-----------------------------------------------------------------
Version 9.03:  05APR96 [STABLE]
     Revised:  Default configuration now for 30° beam angle
-----------------------------------------------------------------
Version 9.04:  16JUL96
 -Requires new boot code version 1.12.
 -Added Deployment Saver (Autostart) mode.
 -Added 'Help' command (does same thing as '?').
 -Modified PT2 to output data from internal moisture sensor.
 -Added recorder test to PA command.
 -Fixed problem where previous alarm indication not cleared,
  which would cause unit to start pinging prematurely at first
  charge wakeup.
 -Added additional checks to TF time to prevent dates and times
  that were not practical (i.e. 31APR, 29FEB on a non-leap year,
  or any time in the past).
 -Fixed manual ping cycling (it did not pause before).
 -Improved the speed of the ping logic.
 -Modified Deployment Saver mode:
  --First Ping Time (TF) is now saved in non-volatile memory, so
    if the system restarts before the TF time is reached, it will
    recover and wait for that same time before starting the
    deployment.
  --Deployment Saver mode stays on after BREAK until valid
    command is entered.
  --Command parameters are automatically saved (CK) in non-
    volatile memory when pinging starts.
```

```
 -The system now powers down when the recorder is full if serial
  output is not enabled.
 -Fixed problem where system would wake up too early and stay
  awake waiting for the correct time to start pinging.
 -Added Calibration Offset to temperature sensor equation.
 -Added &K command to enter temperature offset, and added display
  of temperature offset to PS0 command.
 -Removed code that automatically saved current baud rate in non-
  volatile memory when pinging was started.
 -Fixed problem with usage of First Ping Time (TF), which caused
  an error message to be displayed after the system restarted.
 -Fixed problem where system would hang if code was downloaded
  with the wrong version of boot code.
 -Modified BREAK-detect logic to be more responsive when using
  fast ping rates.
 -Fixed problem in the RAM test code, which caused cold wakeups
  when sending a BREAK after the PA test command was run.
 -The Engineering Rev. value (the number in brackets after the
  firmware version number in the PS0 command output) is 1, so in
  the PS0 command output the firmware version is:  8.10 [1]. The
  Engr. Rev. count was bumped from 0 to 1 because of a couple of
  minor bug fixes found during the valuation of 8.10 [0].
 -Fixed problem with BREAKs getting overridden by clock alarm
  interrupts.
 -Fixed problem with BREAKs not being detected consistently.
 -Fixed recorder bug where first file on second card would be
  skipped during data recovery, or files on first card would be
  downloaded twice. This would occur when using two PCMCIA cards
  of the same size.
 -Updated Speed of Sound calculation to use more accurate
  equation for salt water and depths up to 8000 m.
 -Minor modification to make Temperature Sensor Offset (&k)
  command work better.
 -Fixed recorder problem where deployment names entered in lower
  case caused the creation of filenames that were invisible to
  DOS (DOS cannot handle filenames in lower case).
 -Fixed problem with wild velocities in multiple water-ping data
  with water reference layer averaging enabled and Percent
  Good < 100%.
-----------------------------------------------------------------
Version 9.05:  24JUL96
 -Added commands to the "deploy?' output:  BF, BK, BL, BP, BS, BX
 -Deleted the TF and "W" commands from the "deploy?" output.
 -CB command help now displays actual current baud rate.
 -Firmware now defaults to water profiling disabled.
 -Changed the default of the TE command to 00:00:01.00
-----------------------------------------------------------------
Version 9.06:  30JUL96
 -Disabled auto-powerdown and timeout auto-start
-----------------------------------------------------------------
Version 9.07:  01NOV96
 -Added rotated pitch/roll output
-----------------------------------------------------------------
Version 9.08:  13FEB97
 -Now recognizes new DEMOD version
 -Modified logic for locating and moving beam correction data
  from old location in flash to new location
 -Moved beam correction data to new flash sector
 -Added exponential filter to pressure sensor
 -Added EF command to allow user-input of a pressure sensor
  filter constant
 -Changed depth in speed of sound calculation and variable leader
  to be calculated from the internal pressure sensor if present
  and enabled
 -Fixed bug that caused the critical flash sector not to be
  updated by compass calibration
 -Fixed bug in speed of sound calculation
 -Added BW command for water reference ping interval when BK=1
```

```
 -FLASH memory changes copied from Navigator to allow feature options.
 -Improved compass calibration for ROVs
-----------------------------------------------------------------
Version 9.09:  22SEP97
 -Fixed bugs in Output_Speed_Log_A/B/C that caused instrument
  data to be output even if ship or earth data selected. Same bug
  caused NO data to be output if beam data selected.  Only
  affects PD3/4/5.
 -Changed banner to read "DVL" instead of "DVL" to maintain
  compatibility with software.
 -Added soft break code. CL command restored so system will not
  go to sleep between pings if CL=0. Soft break from command
  prompt is "+++<CR>"; from the ping loop it is "+++".
 -Added low level RS-485 support.
 -Fixed minor 1200-kHz bandwidth test bug.
 -Fixed minor directory structure bug.
 -Fixed bug that caused factory fluxgate data to not be restored
  by AR command. This bug was introduced in 9.08.
-----------------------------------------------------------------
Version 9.10:   19FEB99
 -Added support for the Applied MicroSystems SVSS. Please see 'D'
  commands in the manual.
 -Fixed a bug in Speed Log (PD3) which caused the temp., pitch,
  roll and heading to be improperly averaged.
 -Fixed Byte 32 if the Fixed Leader Data to properly acknowledge
  the presence of a pressure sensor and SVSS.
 -Modified RDS^3 routines.  Please see manuals under Ping
  Synchronization.
 -Fixed BOOT CODE to acknowledge breaks and re-start (i.e.
  no more cycling power.)
 -Added BB command to the bottom-tracking command set. BB lets
  you define the depth at which the DVL switches between 25% and
  50% bandwidths.  A setting of zero disables 50% Bandwidth.
 -Added Terrain Bias to Bottom Tracking Data.
 -Added CPU Serial number to Fixed Leader Data (Bytes 43-50).
 -Added Spare Word to Fixed Leader Data (Bytes 51-52).
 -Added Spare Byte to Variable Leader Data (Byte 57).
 -Implemented ability to turn off AutoStart with CT command.
-----------------------------------------------------------------
Version 9.11:   07JUN99
 -Fixed a bug which caused no time between bottom and water pings
  during the last loop of an ensemble.
 -Changed the default Percent Good Threshold from 25% to 0%.
 -Fixed a bug which caused RDS^3 Slaves to hang.
    The units would hang when connected to the masters and
      the masters were woken up before the slaves.
-----------------------------------------------------------------
Version 9.12:   10AUG01
 -Fixed a bug in the Water Mass Tracking.  Gain was not being
  set correctly.
 -Added PD11 data output format containing NMEA 0183 compliant
  strings for course and speed made good.
 -Added PD13 data output format.  Same as PD6 with the addition
  of the :RA field showing range to bottom and pressure.
 -Added BN command to control behavior of distance accumulation
  when the instrument can't find the bottom.
 -Added the BO command to set the value of the exponential filter
  constant used in calculating accumulated distance.
 -Changed CF Command.  Bin/Hex-ASCII switch now has three valid
  values; 0 = Hex-ASCII, 1 = Binary, 2 = Hex-ASCII w/ <CR><LF>
  between ensembles.
 -Added PF Command.  PF runs the PA Tests but produces a single
  line result: "TEST=X,XXX,XXXXX-XXXXX,XXXX,XXXXXX,X".  The first
  result is the system Go/No Go.  The rest correspond directly to
  the PA Tests.
 -Implemented low latency trigger.  When enabled, the system will
  not sleep to conserve power.  The unit will ping within ~300us
  of the start of the incoming  trigger.
```

```
 -Added CX Command.  CX enables or disables the low latency trigger.
 -Added CA Command.  CA Command enables / disables periodic output.
  When CA is not 0, the unit will out data with a period specified
  by the CA command (in 0.1 seconds).  This mode requires that the
  low latency trigger be enabled.
 -Changed PD0 output format.  Added Bottom Pings (2 bytes) and Water
  Mass Pings (2 bytes) to the end of the Bottom Track Data Type in
  PD0.
-----------------------------------------------------------------
Version 9.13:   23AUG01
 -Added PD10 data output format.  Which is similar to PD3, but
  contains Depth information.
 -Fixed a bug which rendered RS422 Communications in-operable.
 -Fixed a bug which caused tests to wait for a trigger.
-----------------------------------------------------------------
Version 9.14:   18DEC01
 -Updated for 150 kHz Navigator.
 -Fixed a bug caused when using cfxx2xx.  Removed extra <CR>.
 -Re-wrote AMS SVSS interface code.
 -Implemented a reduced bandwidth bottom track (BM6).
 -Added 9 spare bytes to the Fixed Leader.
 -Fixed Bug #359, which caused velocity truncation when applying
  terrain bias.
 -Fixed Bug #370, Removed ability to lag hop while bottom
  tracking, was un-reliable.
 -Fixed Bug #416, Error velocity screening is now disabled in
  all coordinates by setting WE to 0.
-----------------------------------------------------------------
Version 9.15:   04APR2002
 -Implemented NMEA $--HDT sentence input via command interface
  while pinging.  To enable this set the heading switch in the
  EZ Command to '3'.  Do exceed 10 Hz refresh rate.  Sentence is
  to comply with NMEA standard version 3.0 dated 7/1/2000.  The
  Checksum is not optional.  The serial format must be 8-bit and
  comply with the CB command settings.
-----------------------------------------------------------------
Version 9.16:   03MAY2002
 -Fixed a bug which caused incorrect averaging in Water Modes
  5 & 8.  The bug averaged zeros into the RSSI & Correlation
  when the bottom was closer than the requested profile range.
 -Fixed a bug in the NMEA $--HDT sentence input.  Calls to another
  function were clearing the HDT data from the input buffer and
  echoing them to the console.
-----------------------------------------------------------------
Version 9.17:   28MAY2002
 -Fixed two bugs in how the COG and COW(Layer) were computed for
  PD11.  One caused the direction to be 180 deg out.  The other
  caused the direction to be calculated referenced to East and
  increasing counter-clockwise.
-----------------------------------------------------------------
Version 9.18:   16APR2004
 -Modified to prevent system hang-up when WI is enabled.
 -Corrected checksum calculation to allow serial settings to survive breaks.
 -Modified to ensure that the MSNibble of the serial parameters is cleared.
 -Modified to remove redundant '\r' chars in the SPEED2 outputs.
 -Ported BM7 from Navigator.
 -To prevent loss of features during firmware update, forced Cold wakeup on
update.
 -Modified Fixed Leader Output to match other products.  In particular, the
Base Frequency Index was moved from byte #59 to byte #54 to avoid a conflict
with HDVL-WH.
 -Changed default source of depth data from manual input to sensor input.
 -Changed prompt for CL to reduce confusion.
 -Ported over code to support the Y2K compliant Date/Time commands (TG & TT)
from WHM/S/LR.
 -Added save and restore for BT_Bandwidth_Sw_Depth, BM7Blank,
BTM7CorrelationThreshold and BM7ShortLagOutput.
 -Changed default for 300KHz Terrain Bias from 1005 to 1003.
```

```
 -Restored lag hopping code to BM4
 -Changed default value of TestSwitchesSelected (&O) to 0x0001 to disable
lag hopping.
-----------------------------------------------------------------
Version 9.19:   24MAR2005
 -Added the ability to enable output of data when only 1 or 2 beams have
valid data when in beam mode.
-----------------------------------------------------------------
Version 9.20:   28JUL2005
 -Corrected handling of negative EB values.
 -Corrected output of the heading in the variable leader.
=================================================================
```

19 Application Notes

FSA #	Description
App Note 7	Design of a sea chest
FSA-007	The Effect of a Moving Bottom Condition
FSA-010	Vessel-Mounted ADCPs and Windows for Sea Chests
FSA-012	Configuring Bottom Track Mode 6
FSA-015	Shallow Water Bottom Tracking Bottom Mode 7
FSA-017	Using NMEA Heading Strings
FSA-018	Trigger DVL with TTL Signal
FSA-019	ADCP Beam Clearance

Application Note 7 - Conceptual Design of a Sea Chest

Introduction

This application note describes a conceptual design for a sea chest in which to mount the transducer of an TRDI transducer. The sea chest design is intended to allow the following:

a. Proper functioning of the ADCP.

b. Diver-assisted installation and removal of the transducer without requiring dry-dock.

c. Access to the transducer electronics from within the vessel without requiring removal of the transducer assembly (requires optional adapter plate, 303A1066).

d. Installation of the sea chest in the shipyard or dry dock followed by installation of the transducer assembly at an alternate time when the vessel is dockside in a port.

The note shows conceptual drawings and lists considerations for producing a detailed design of a sea chest for an TRDI transducer. Detailed drawings of TRDI's transducers are available upon request from TRDI.

Figure 55, page 294 shows a side view of a transducer and sea chest, and Figure 56, page 295 shows the sea chest in more detail. Figure 57, page 295 and Figure 58, page 295 shows an alternate sea chest/gate valve installation. Figure 59, page 296 shows a plan view of the profiler dome.

Definitions

Hull: the outer skin of the vessel.

Profiler Dome: this is a streamlined cover that protrudes below the hull. It is used to protect the transducer, to allow it to be mounted horizontally on a sloping hull, and to position the transducer on the hull so that its beams pass unobstructed by the hull. The streamlined shape can help divert bubbles away from the transducer beams. In many installations, particularly where the hull is flat and horizontal, a profiler dome may not be used.

Sea Chest: this fixture surrounds and holds the transducer, protecting it from debris in the water. The bottom of the sea chest must be open to seawater to allow the acoustic beams to pass through without any obstruction of any kind.

Well: this is the cavity inside the sea chest in which the transducer cup assembly is located.

Spool: this is the cylindrical part of the sea chest that surrounds the transducer. The Top Flange is used to bolt on the Top Mounting Plate, and the

Lower Flange is used to bolt on the Bottom ***Cover Plate***. The Lower Flange has two alignment marks defining a line that should be parallel to the keel of the vessel. The mark that is to be positioned forward is indicated with the mark ‘FWD’.

Bottom Cover plate: this may be used to cover the sea chest to allow the transducer assembly to be removed from the sea chest and withdrawn inside into the vessel. The cover plate is intended to be installed by a diver. It is equipped with handles to assist diver installation and removal.

Top Mounting Plate: this plate is part of the sea chest and it is used to mount the transducer. The plate is equipped with two eyebolts to allow lifting the transducer/plate assembly during installation or removal.

Top Cover Plate (not shown): this is a blank plate that can be mounted in place of the transducer and Top Mounting Plate to allow operation of the vessel when the transducer and the Bottom cover Plate are removed.

Transducer: this is supplied as part of the ADCP, and it transmits and receives the acoustic signals used to measure water velocity.

Transducer Cup Assembly: this is the part of the transducer below the Transducer Adapter Plate that is in contact with the seawater, and it contains the transducer acoustic elements that transmit and receive the acoustic signals. Each cup holds one transducer piezoelectric ceramic.

Transducer Adapter Plate: this is a round plate that is an optional part of the transducer used for attaching the transducer to the Top Mounting Plate.

Transducer cable: this is a 23-mm diameter cable that is run from the ADCP system electronics to the transducer.

Top Hat: this is the top part of the transducer that covers the transducer electronics printed circuit boards. It is designed to allow these circuit boards to be removed for servicing from inside the vessel without having to remove the transducer.

Vent Pipe and Vent Ball Valve: these allow air trapped inside the well to bleed off so that air will not build up and interfere with acoustic transmission. The Vent Ball Valve allows the Vent Pipe to be closed for servicing.

Drain Pipe and Drain Valve: these are used to allow excess water to be drained from the well and to test water-tightness of the Bottom Cover Plate seal, just after it is installed. The Drain Pipe also allows the well to be pressurized to test water-tightness of the Top Cover Plate or Top Mounting Plate after they are installed

Design Considerations

The following are general design considerations for designing a sea chest for an TRDI ADCP. Individual situations will differ, and there may be additional factors to be considered in the design.

1. Transducer location

The transducer should be located as close as possible to the keel of the vessel, and located somewhere in the middle third of the vessel, between the bow and the propellers. The transducer should be far from the propellers to minimize noise caused by propeller cavitation, and it should be far from the bow to minimize the amount of bubbles entrained under the ship's hull at the bow.

2. Sloping hull

The transducer may be mounted in a sloping hull as long as there is no possibility of interference with the acoustic beams. This means that a 15º cone around the beams must be kept clear, as shown in Figure 5.

3. Height of the Transducer inside the Sea Chest

The transducer should be held inside the Sea Chest in a position where it will not be able to collide with debris passing by the vessel in the water. Generally this means that the bottom of the transducer can be about even with the opening at the bottom of the Sea Chest.

4. Orientation of the transducer

The Sea Chest should be positioned so that the transducer is horizontal when the ship is underway at a normal speed.

The Transducer Adapter Plate, the Top Mounting Plate and the Spool all have alignment holes drilled for spring pins to align them relative to one another. The Sea Chest must be aligned with the axis of the vessel; if it is aligned perfectly, then the alignment holes will ensure that the transducer also aligns within 0.05º of the axis.

Note, however, that it is possible to determine the orientation of the transducer relative to the axis of the ship by statistically analyzing data collected by the ADCP over a period of time, say a few weeks or a month. TRDI's data acquisition system is able to correct data for different alignments.

5. Vent Pipe

The Vent Pipe should be attached near the top of the Spool where air bubbles will collect. It must be terminated above the water line, and left open to allow air to vent from the well. The pipe diameter must be large enough to ensure that the pipe does not become clogged. The wall thickness of the pipe should be large to ensure that the pipe will withstand corrosion during the lifetime of the ship. The top termination of the pipe should have a means for attaching a water hose so that the pipe can be periodically flushed to clear out collected debris.

6. Drain Pipe and Drain Valve

The Drain Pipe should be attached to the Spool near where the Vent Pipe is attached. It should be terminated well below the water line of the vessel and it should have a means for attaching a water hose to allow the well to be pressurized when testing the seal. Because the Drain Pipe is terminated below the water line, the Drain Valve should be difficult to open (e.g. requiring a wrench), it should open slowly (i.e. as would a gate valve) so that a worker is not surprised by a sudden onrush of cold water, and the Drain Pipe outlet should be directly next to the valve (so that the worker can see the consequence of his actions when opening the valve). The pipe diameter and thickness requirements for the Drain Pipe are the same as for the Vent Pipe.

7. Bottom Cover Plate Attachment Screw Holes

The screw holes in the spool must be protected when the bottom cover plate is not attached. This is done by filling the screw holes with polysulfide sealant, screwing stainless steel set screws into the holes and filling over the set screws with polysulfide sealant.

8. Assisting Diver Installation

There should be several padeyes welded to the hull near the sea chest to which the diver may attach rope or cables. These will allow him to obtain leverage when installing or removing screws for the cover plate, and for temporarily supporting the cover plate while preparing to install it. The padeyes should have a low profile to minimize the chances that they would be torn off while the vessel is in operation.

9. Sealing Against Seawater

All joints exposed to seawater should be sealed with an appropriate gasket material.

10. Installation of Vent and Drain Pipes

Both pipes should be welded in place with welds both on the inside and on the outside of the Sea Chest.

11. Paint

All welded surfaces and any other surfaces where paint is damaged should be cleaned and repainted.

12. Corrosion Protection

The Top Mounting Plate requires a reliable electrical connection to the hull, such as a grounding strap. The remainder of the sea chest assembly is protected by the ship's cathodic protection system. The transducer is manufactured with naval bronze and does not require cathodic protection.

13. Access to the Transducer

The transducer assembly must be accessible from within the inside of the vessel to allow installation and removal of the assembly. There must be sufficient headroom to allow the transducer to be fully withdrawn from the well. The deck above the transducer should have eyebolts or other means to attach ropes to lift the transducer and there should be sufficient room for people to work in.

14. Protrusion of the Profiler Dome

The Profiler dome should protrude about 10 cm below the hull to get it below layers of bubbles that might follow the hull while the ship is underway. Bubbles can also be steered away from the well by streamlining the dome with the shape reducing to points both fore and aft (Figure 3).

15. Dimensional Considerations; Clearances

Each vessel installation will have its own dimensional considerations depending on the type of system to be installed, the kind of use the vessel typically gets and the size, shape and construction of the vessel. The inner dimensions of the well are controlled by the transducer. The transducer should not protrude outside the well but may be flush with the bottom of the well. The clearance between the well and the transducer must only be large enough for simple installation.

In some cases, the well may be made larger than is required so that a larger, lower-frequency transducer could be installed in the future. Above the well there must be adequate room for the transducer cable and to allow the transducer to be removed. There must also be adequate working space for the persons who will have to work on the transducer.

For bolting the Top Cover Plate or the Top Mounting Plate to the Top Flange, there should be adequate clearance to handle nuts located under the flange. If there is inadequate room to reach the nuts, an alternative is to tap the Top flange and to install studs.

Procedure for Installing and Removing the Transducer

The following sequence is in proper order for removal of a transducer. The same procedure, in reverse, should be used to install the transducer.

1. Checking the Drain Pipe for Obstructions

The Drain Pipe should be checked for obstructions by opening the Drain Valve to see if water flows freely. If the hydrostatic pressure of the seawater is insufficient to drive a steady flow, attaching a water hose to the end, opening the valve and applying water pressure of at least 50 psi should clean the drain valve.

2. Installation of the Bottom Cover Plate

Divers should first clean marine growth from the Lower Flange on the Spool of the Sea Chest. Then they should remove the setscrews from the Lower Flange of the Spool. For leverage, the divers may attach handholds to padeyes welded to the hull near the Sea Chest.

Divers may carry the Bottom Cover Plate to the Sea Chest with the help of flotation. Once there, the plate should be supported with ropes attached to padeyes on the hull and eyebolts on the plate. The plate may be maneuvered into position, then attached to the Lower Flange with bolts. The plate should be sealed with a rubber gasket. After the plate is installed, the ropes supporting the plate may be removed.

3. Testing the Bottom Cover Plate Seal

Close the Vent Ball Valve, then fully open the Drain Valve. If the Bottom Cover Plate is sealed, then there will be no drainage from the Drain Pipe except for perhaps a small amount at first. Any steady drainage indicates that the seal is imperfect. If the seal is acceptable, open the Vent Ball Valve and drain excess water in the Vent Pipe out of the Drain Pipe into a bucket.

4. Removal of the Top Cover Plate

Remove the bolts attaching the Top Cover Plate to the Spool and remove the entire plate and transducer assembly. Bail excess water out of the well.

5. Installation of the Transducer to the Top Mounting Plate

Attach the Top Mounting Plate to the Transducer Adapter Plate with lock nuts, using a gasket between the plates. Use spring pins to align the two plates. Position the transducer and Transducer Adapter Plate assembly over the Sea Chest, supporting it with ropes through the Top Mounting Plate eyebolts. Orient the assembly in the approximate position that it will be installed in, and lower it into place. Use roll pins to align the assembly with the Top Flange of the Spool. Seal the joint with a gasket. Fasten the Top Mounting Plate to the Top Flange with bolts and nuts.

6. Testing the Seal

Close the Vent Ball Valve and attach a water hose to the Drain Pipe. Apply at least 50-psi pressure to the water hose and inspect the joints. If no leakage or dampness is visible around the seal areas, then the seal is acceptable. If the well is filled with air, then soapy water should be brushed onto the seal to see if air bubbles leak out.

7. Checking the Valves

At this time, both the Vent Ball Valve and the Drain Valve should be checked to be sure that the Vent Ball Valve is open and the Drain Valve is closed. ***If the Drain Valve is left open, the compartment will flood when the Bottom Cover Plate is removed.*** If the Vent Ball Valve is closed, then air will not properly bleed from the well and ADCP performance will be affected.

8. Removal of the Bottom Cover Plate

Divers should first attach ropes between the Bottom Cover Plate handles and the padeyes on the hull to support the cover plate once its bolts are removed. The bolts may be removed and the cover plate allowed to dangle out of the way on a single line. Polysulfide sealant should then be applied inside the bolt holes, filling them, and the stainless steel setscrews should be screwed back in. Excess sealant will be extruded from the holes. After the setscrews are in place, additional sealant should be used to fill and seal the remaining cavity. The cover plate may then be carried back to the dock with the help of flotation.

9. Flushing the Vent Pipe

After the Bottom Cover Plate is removed, attach a hose to the outlet of the Vent Pipe and apply at least 50-psi water pressure. This flow of water will clear any material that has collected inside the pipe, freeing any clogs. The sound of the water flowing should be easily detected; if the pipe is clogged, then it must be unclogged. This procedure should be repeated periodically to keep the pipe open.

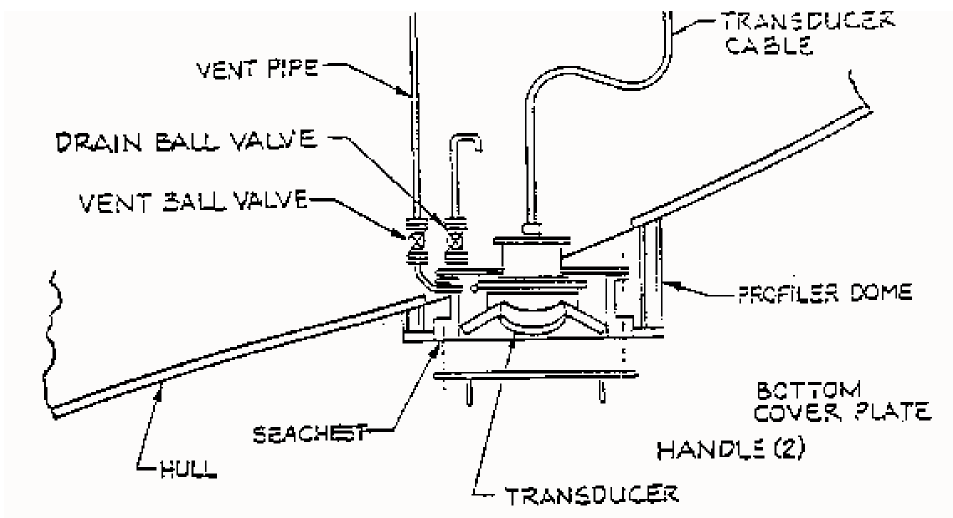


Figure 55. Side View of Transducer and Sea Chest in a Sloping Hull

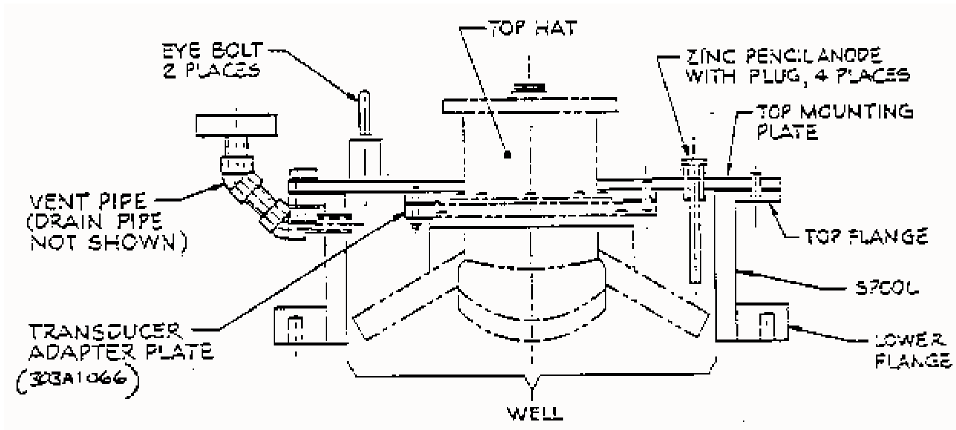


Figure 56. Expanded View of a Sea Chest

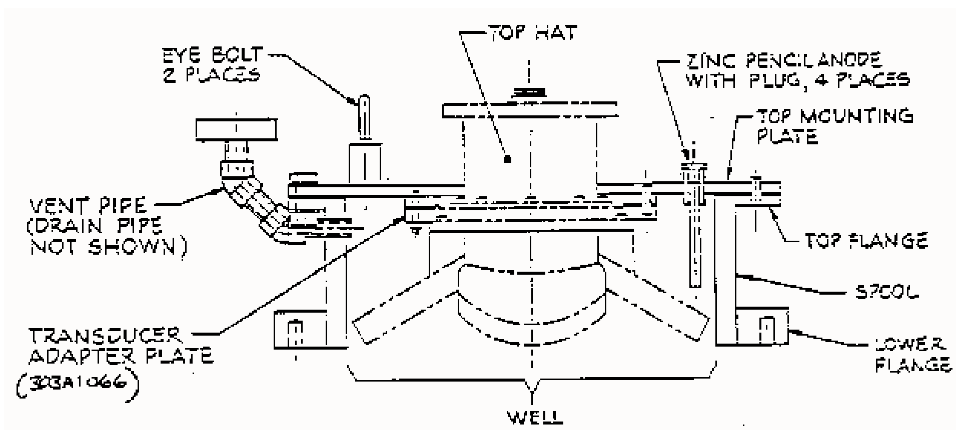


Figure 57. Stemmed Transducer using a Three Inch Gate Valve

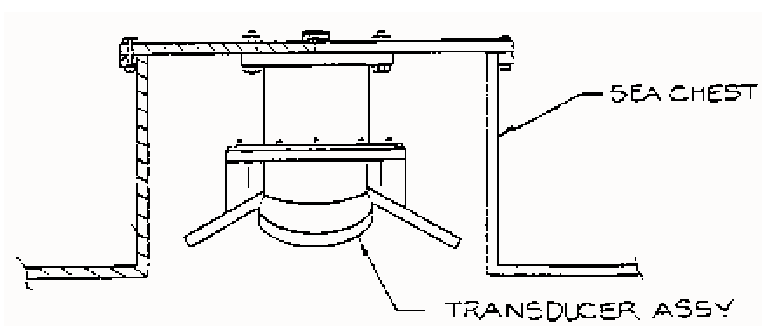


Figure 58. Transducer Without Stem

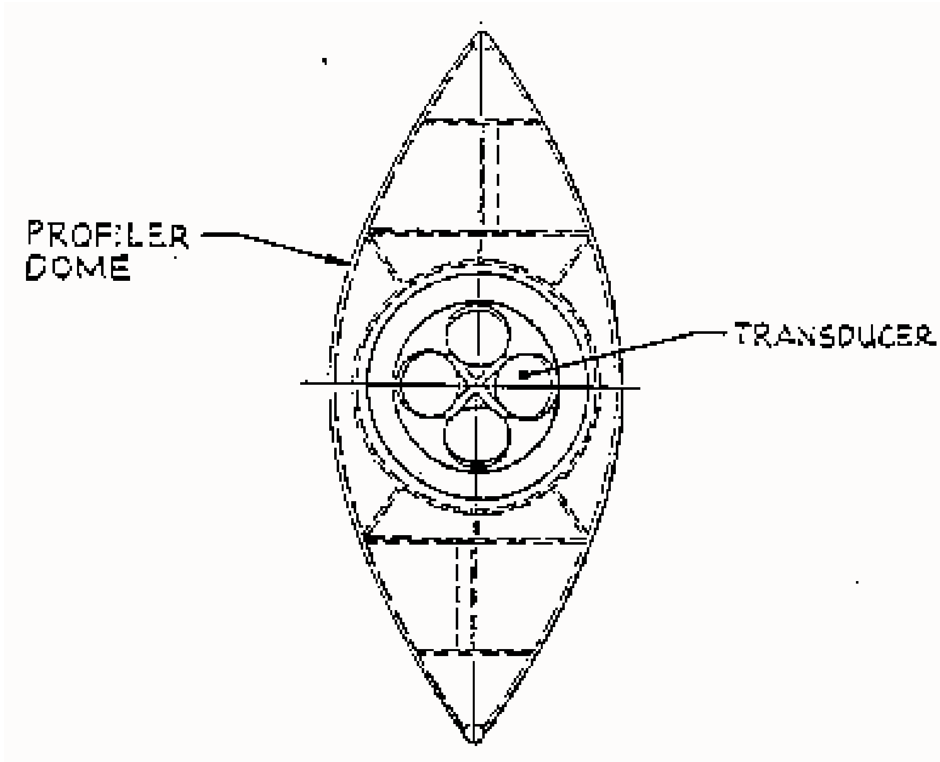


Figure 59. Profiler Dome

FSA-007 - Effect of a Moving Bottom Condition:

In High Flow (Flood) or High Sediment Concentration Conditions

Conditions Characterized by:

- Unstable (Moving) Bottom
- High Suspended Sediment Near River Bed
- Biased Bottom Track Data
- High Water Velocities

Not Characterized by:

- Stable Bottom
- Unbiased Bottom Track
- Valid Bottom Track Depths

Introduction

The primary function of bottom-track is to measure the ADCP’s speed-over-bottom and detected range-to-bottom. In the discharge calculation, these two pieces of information are used to:

Calculate the absolute water velocity by subtracting the boat’s velocity from the relative water velocity measured by the ADCP,

Estimate the cross-sectional area of the transect.

During high flow or high sediment concentration conditions, the environment may result in biased bottom track measurements. When the bottom track data is biased, it is necessary to have an external means for estimating the boat’s velocity.

Measuring Discharge when Bottom Track Velocity Data is Biased

Differential GPS (dGPS) provides this means to estimate the boat’s velocity while underway. The dGPS calculates the boat’s position to an accuracy of about 1-3m and supplies it every second or so. These waypoints can be differentiated to calculate the boat’s velocity. *TRANSECT v. 4.04* and higher incorporates the GPS data into the real-time calculation of discharge. For more information on using differential GPS, refer to the When to Use Differential GPS in Place of Bottom Track application note and Appendix D - Using GPS and Depth Sounders of the TRANSECT 4.0 Manual.

Bottom Detection in High Suspended Sediment Concentrations

In order for the ADCP to correctly detect the bottom, the signal reflected from the bottom must be significantly higher than the signal reflected from the suspended scatterers in the water column. If there is a high sediment concentration near the bottom, there may not be enough contrast between the water and bottom returns, and the ADCP will not detect the true range to the bottom.

Some users have gotten around this problem by using a lower frequency ADCP. The lower frequency allows the acoustic signal to “punch through” the suspended sediment and better detect the bottom. The reason for this is that the acoustic wavelength longer for lower frequency systems, and these longer wavelengths are not as effectively backscattered by the water. This allows for more contrast between the reflected energy of the suspended particles and the highly reflective bottom. If a valid detection of the bottom cannot be made by the ADCP, *TRANSECT v. 4.04* (and higher) can be used to integrate depth sounder data in place of bottom track depths in the discharge calculation.

Symptoms of Biased Bottom Track Measurements

If one or more of the following occurs, it is an indication of bias in the bottom tracking data:

The *course made good* is longer than expected.

The shiptrack plot shows an upstream offset compared to the actual track taken by the boat.

If you hold station at a position in the channel, the shiptrack indicates that you are moving upstream.

Discharge is lower than expected and not reproducible to better than 5%

> **NOTE.** The ADCP is not malfunctioning – but the moving bottom conditions lead to biased data.

Identifying Bottom Track Bias

You can test your measurement site to identify if the bottom track velocities are biased. In the *TRANSECT* **ACQUIRE** module, press **F4** to start pinging. Hold or anchor the boat in a fixed position near the center of the channel (where the flow and depth is greatest). Press **F5** to start recording data. Keep the boat as stationary (“on-station”) as possible (small ship movements are unavoidable). In Transect, switch to the SHIPTRACK display (ShipTrack - Bottom Track). When you begin to see data being plotted on the shiptrack display, press **Alt-Z** to “zoom in”. Continue holding your position for 5 to 10 minutes.

If you begin to see a red shiptrack plot moving in a general upstream direction (against the river flow direction) as shown in Figure 60, page 299, you have biased bottom track velocities. This is also identified by a steadily increasing value for “Made Good” on the right side of the Transect screen. When you have acquired your desired amount of data, press **F5** to stop recording.

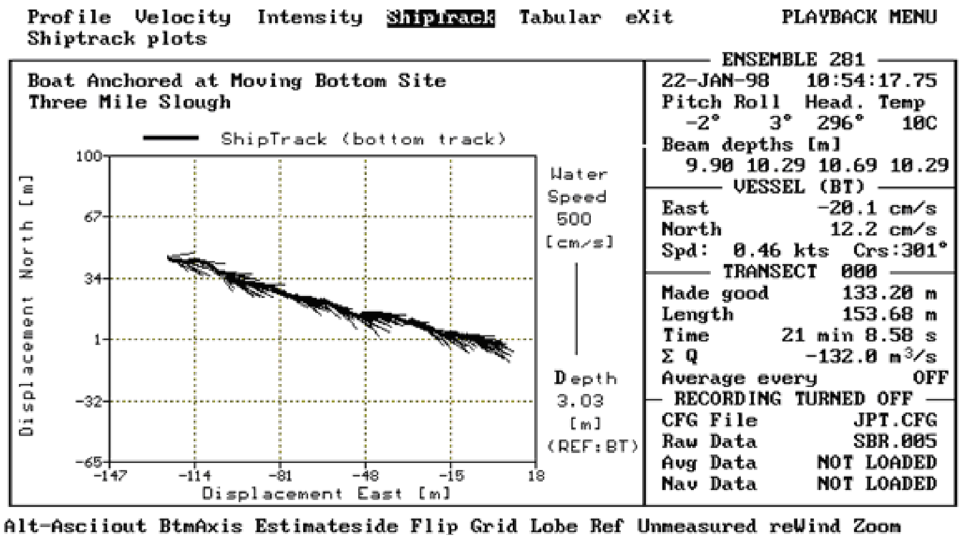


Figure 60. Ship's Track showing Bottom Track Bias

To determine if the bottom motion is fast enough to significantly affect your discharge values, divide the displacement reported by the ship's track plot by the time spent holding of the value of the water flow, it will only introduce a 1.6% error in the discharge, and Bottom Track can by used as the velocity reference. If the value is greater than 1/60th, you should use dGPS in place of Bottom Track as the velocity reference. Another way to look at this is that you can accept one ft/min of bottom motion per 1ft/sec of water velocity. For example, if the water velocity is 5 ft/sec, than we can neglect bottom motion if it is less than 5 ft/min.

Effects of Biased Bottom Track Velocities

In high flow (flood) and high sediment concentrations, the environmental conditions are such that it may become difficult to make valid bottom track measurements, and in some cases with extremely high turbidity, the ADCP cannot measure water profiles due to very high levels of absorption. A schematic of the environmental conditions is shown Figure 61, page 300.

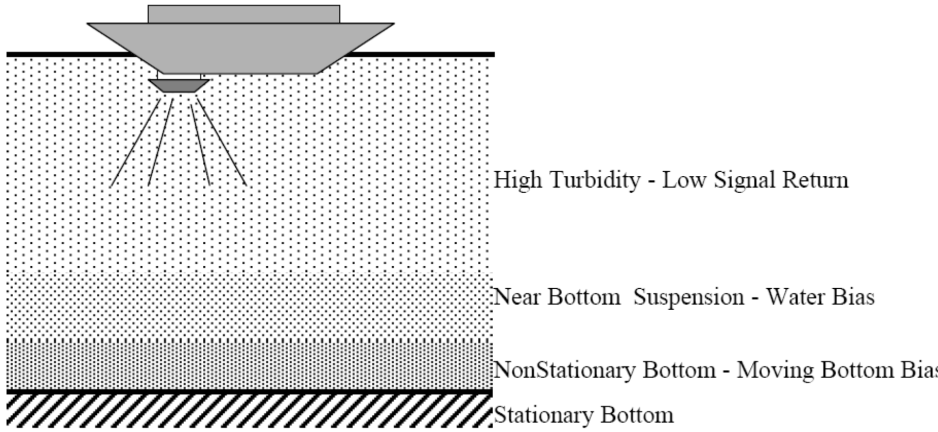


Figure 61. High Flow & Sediment Concentration Effects on Water Profiling & *Bottom Tracking*

Environmental Sources of Biased Bottom Track Velocities

There are two environmental sources that can produce biased values for ADCP bottom track velocities.

a. High sediment concentration in the water column (Water Bias)

   During the time that the bottom tracking sound pulse is in contact with the riverbed (river bottom), echoes (backscattered energy) from the sediment in the water are mixed with the echo from the river bottom. Since this near-bottom water is moving and the bottom is not moving, the mixing of the "water mass" echo with the bottom track echo biases the true velocity over ground.

b. Fluid layer of sediment flowing along the bed of the stream (Moving Bottom)

   If the streambed is actively transporting sediment, it is not a good stationary reference for making bottom track measurements. In this case, the ADCP assumes that the bottom is stationary and the ship's track will show an upstream path when the boat is anchored.

FSA-010 - Using Acoustic Windows

Introduction

Teledyne RD Instruments (TRDI) builds Acoustic Doppler Current Profilers (ADCP) for use on vessels. Installation of an ADCP in a vessel is done in many ways, but typically the ADCP transducer is mounted inside of a sea chest or well. The opening of the sea chest or well can be open to the ocean or an acoustic window can cover it.

An acoustic window is a covering that can seal the opening of the sea chest but still allow the acoustic signal (both transmit and received signals) to be transferred through the window. The type, thickness, orientation, and other installation issues of the acoustic window are important to understand. If the wrong material is used or the wrong installation used then the performance obtained by the ADCP will be severely limited.

Background - Should I use an Acoustic Window?

Like any vessel-mount, acoustic system, the performance of the ADCP is sensitive to acoustic noise. For best performance, the transducer is mounted in its own well, recessed in the vessel hull, with an opening slightly larger than the transducer. An Acoustic Window, mounted across the well opening, is required to isolate the transducer face from flow noise, as the vessel moves through the water. Acoustic windows (or simply windows) can produce overall performance improvements in vessel-mounted ADCPs through the following advantages.

Advantages

Well will not fill with air bubbles caused by the ship moving through the surface water.

Flow noise is reduced.

The well can be filled with fresh water to limit corrosion.

Barnacles cannot grow on the transducer faces. Barnacle growth is the number one cause of failure of the transducer beams.

The transducer is protected from debris floating in the water.

Although these advantages are important, it should be known that if the wrong window is used or if the window is not installed properly then the following disadvantages are possible.

Disadvantages

The range of the ADCP can be reduced because the window will absorb some of the transmit and receive energy.

The transmit signal could be reflected into the well, causing the well to “ring” like a bell. This will cause the data being collected during the ringing to be biased. Some ships have reported a loss in range as great as 50 meters. Applying sound absorbing material on the well walls may dampen the ringing.

The transmit signal could be reflected off of the window and back into the other beams.

However, even though there are disadvantages possible our experience has shown that when the correct window is used and it is properly installed that the window advantages are far more important. The remainder of this Application Note will focus on how to choose the window for your vessel, how to mount the window, how to maintain the window, and any other associated concerns when using a window.

What Window should I use?

While we cannot claim to understand every window, we do believe that we can recommend a material that will work. We have developed a simple model for an acoustic window made from polycarbonate material. Over the past 2 decades we have obtained feed back from customers that has allowed us to prove the model is a fair estimation of what to expect for performance. Polycarbonate was chosen because it can provide enough strength for most installations, is readily available in most countries, it has been shown to last a long time (over 7 years in some installations), and it can be used on all ADCP models (NarrowBand *(NB)*, BroadBand *(BB)*, WorkHorse *(WH)*, and Ocean Surveyor *(OS)*).

The type of ADCP model is very important when choosing a window. The bandwidth of the acoustic signal from the ADCP must be maintained. Different window materials have different losses over a band of frequencies. As an example, the Ocean Surveyor/Observer ADCP uses a bandwidth of 6% or 1% about the system’s center frequency. A BroadBand or WorkHorse ADCP uses a bandwidth of 25% or 6% about the system’s center frequency. The material polycarbonate has a fairly uniform loss about these frequency bandwidths.

It should be noted that we have no knowledge about the variability of polycarbonates. And so, the acoustic model that we run is for a particular polycarbonate manufactured by Zelux. This is a window-grade, polycarbonate and has a high tensile strength (~9000psi) to resist cracking.

Even when choosing this particular window it is important to choose the proper thickness of window material. A window will absorb sound and reduce the range of the ADCP. Therefore, we always recommend using the thinnest window possible. However, depending on your application a thicker material may be necessary. The following table indicates the expected loss (two-way) of polycarbonate at different frequencies and thickness.

Table 72: Expected Loss for ADCPs with 30Degree Beam Angle

Frequency (kHz)	Thickness mm (in.)	One-way loss @ 0°,20°,40°C (dB)			Two-way loss @ 0°,20°,40°C (dB)			Expected Loss in Range (meters)
38	76.2 (~3.0)	2.7	2.6	2.3	5.4	5.2	4.6	173
38	63.5 (~2.5)	3.0	2.9	2.5	6.0	5.8	5.0	192
38	50.8 (~2.0)	2.9	3.2	2.9	5.8	6.4	5.8	205
38	***38.1 (~1.5)***	***1.4***	***1.2***	***1.0***	***2.8***	***2.4***	***2.0***	***90***
38	25.4 (~1.0)	2.9	3.3	3.3	5.8	6.6	6.6	211
38	**19.1 (~0.75)**	**1.0**	**0.9**	**0.8**	**2.0**	**1.8**	**1.6**	**64**
38	12.7 (~0.5)	5.3	5.8	5.6	10.6	11.6	10.2	371
38	9.5 (~0.375)	1.8	1.8	1.8	3.6	3.6	3.6	115
38	6.4 (~0.25)	0.7	0.7	0.6	1.4	1.4	1.2	45
75	76.2 (~3.0)	4.2	4.3	3.8	8.4	8.6	7.6	138
75	63.5 (~2.5)	3.9	4.0	3.5	7.8	8.0	7.0	128
75	50.8 (~2.0)	3.6	3.6	3.0	7.2	7.2	6.0	115
75	38.1 (~1.5)	2.7	2.6	2.3	5.4	5.2	4.6	83
75	25.4 (~1.0)	3.1	3.3	2.9	6.2	6.6	5.8	106
75	***19.1 (~0.75)***	***1.4***	***1.2***	***1.0***	***2.8***	***2.4***	***2.0***	***45***
75	12.7 (~0.5)	3.1	3.5	3.3	6.2	7.0	6.6	112
75	**9.5 (~0.375)**	**1.0**	**0.8**	**0.7**	**2.0**	**1.6**	**1.4**	**32**
75	6.4 (~0.25)	5.9	6.3	5.5	11.8	12.6	11.0	202
150	50.8 (~2.0)	5.0	5.2	4.6	10.0	10.4	9.2	83
150	38.1 (~1.5)	4.2	4.4	3.8	8.4	8.8	7.6	70
150	25.4 (~1.0)	3.6	3.6	3.0	7.2	7.2	6.0	58
150	***19.1 (~0.75)***	***2.7***	***2.6***	***2.3***	***5.4***	***5.2***	***4.6***	***43***
150	12.7 (~0.5)	3.1	3.3	2.9	6.2	6.6	5.8	53
150	**9.5 (~0.375)**	**1.4**	**1.2**	**1.0**	**2.8**	**2.4**	**2.0**	**22**
150	6.4 (~0.25)	3.2	3.6	3.3	6.4	7.2	6.6	58
300	25.4 (~1.0)	5.0	5.2	4.5	10.0	10.4	9.0	42
300	19.1 (~0.75)	4.2	4.3	3.8	8.4	8.6	7.6	34
300	12.7 (~0.5)	3.6	3.6	3.0	7.2	7.2	6.0	29
300	***9.5 (~0.375)***	***2.7***	***2.6***	***2.3***	***5.4***	***5.2***	***4.6***	***22***
300	6.4 (~0.25)	2.9	3.4	3.2	5.8	6.8	6.4	27

TRDI's recommended thickness is in **blue bold**. TRDI's recommended maximum thickness is in ***red italic and bold*** in the above table. All other items will result in poor overall performance or a loss in range that most customers find unreasonable.

One-way insertion loss curves for all items above in **bold** (TRDI's recommended thickness) are found in Appendix A of this application note. All other plots are available from TRDI upon request.

Note all of the losses and expected ranges are estimated and some of the assumptions we make may not be true in your installation. However, based on several actual installations the values shown have proven to be good estimations. Your actual loss may be higher or lower than what is shown.

Table 73: Expected Loss for ADCPs with 20Degree Beam Angle

Frequency (kHz)	Thickness mm (in.)	One-way loss @ 0°,20°,40°C (dB)			Two-way loss @ 0°,20°,40°C (dB)			Expected Loss in Range (meters)
38	76.2 (~3.0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
38	63.5 (~2.5)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
38	50.8 (~2.0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
38	***38.1 (~1.5)***	***N/A***	***N/A***	***N/A***	***N/A***	***N/A***	***N/A***	***N/A***
38	25.4 (~1.0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
38	**19.1 (~0.75)**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
38	12.7 (~0.5)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
38	9.5 (~0.375)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
38	6.4 (~0.25)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
75	76.2 (~3.0)	3.1	3.2	2.8	6.2	6.4	5.6	102
75	63.5 (~2.5)	2.7	2.8	2.6	5.4	5.6	5.2	90
75	50.8 (~2.0)	2.6	2.6	2.3	5.2	5.2	5.6	90
75	38.1 (~1.5)	2.0	2.0	1.8	4.0	4.0	3.6	64
75	25.4 (~1.0)	2.2	2.1	1.8	4.4	4.2	3.6	70
75	***19.1 (~0.75)***	***0.9***	***0.9***	***1.0***	***1.8***	***1.8***	***2.0***	***32***
75	12.7 (~0.5)	2.8	2.9	2.4	5.6	5.8	5.4	93
75	**9.5 (~0.375)**	**1.0**	**0.9**	**0.8**	**2.0**	**1.8**	**1.6**	**32**
75	6.4 (~0.25)	4.2	3.7	2.7	8.4	7.4	5.4	134
150	50.8 (~2.0)	3.6	3.8	3.4	7.2	7.6	6.8	61
150	38.1 (~1.5)	3.1	3.2	2.8	6.2	6.4	5.6	51
150	25.4 (~1.0)	2.6	2.6	2.3	5.2	5.2	4.6	42
150	***19.1 (~0.75)***	***2.0***	***2.0***	***1.8***	***4.0***	***4.0***	***3.6***	***32***
150	12.7 (~0.5)	2.2	2.1	1.8	4.4	4.2	3.6	35
150	**9.5 (~0.375)**	**0.9**	**0.9**	**0.9**	**1.8**	**1.8**	**1.8**	**14**
150	6.4 (~0.25)	2.9	2.9	2.3	5.8	5.8	5.6	46
300	25.4 (~1.0)	3.6	3.8	3.4	7.2	7.6	6.8	30
300	19.1 (~0.75)	3.1	3.2	2.8	6.2	6.4	5.6	26
300	12.7 (~0.5)	2.6	2.6	2.3	5.2	5.2	4.6	21
300	***9.5 (~0.375)***	***2.0***	***2.0***	***1.8***	***4.0***	***4.0***	***3.6***	***16***
300	6.4 (~0.25)	2.2	2.1	1.8	4.4	4.2	3.6	18

TRDI's recommended thickness is in **blue bold**. TRDI's recommended maximum thickness is in ***red italic and bold*** in the above table. All other items will result in poor overall performance or a loss in range that most customers find unreasonable.

One-way insertion loss curves for all items above in **bold** (TRDI's recommended thickness) are found in "Insertion Loss," page 313. All other plots are available from TRDI upon request.

Note all of the losses and expected ranges are estimated and some of the assumptions we make may not be true in your installation. However, based on several actual installations the values shown have proven to be good estimations. Your actual loss may be higher or lower than what is shown.

Are there any Other Windows that I can consider?

TRDI has only limited experience with other materials. As a result there is not much information we can provide about other materials. However, we can state that different materials will behave differently, depending on both the frequency and bandwidth of the acoustic ADCP signal. The absorption curves of various materials have significant amplitude fluctuations with frequency, which can change in both frequency and amplitude with changes in temperature.

Important acoustic properties of the window include acoustic refractive index (which should be as close as possible to that of water), insertion loss (which should be as small as possible) and speed of sound. There are two acoustic refractive indices: one for shear waves and one for plane waves. The acoustic refractive indices are simply the ratios of speed of sound in water to speed of sounds in the material. Insertion loss combines absorption and reflection of sound, and it depends on both the thickness and the material properties of the window. In particular, you should avoid using window thickness equal to odd multiples of shear mode quarter-waves (Dubbelday and Rittenmeyer, 1987; Dubbleday, 1986). Refer to Selfridge (1985) and Thompson (1990) for more information. Note that the speeds of sound in plastics decrease with increasing temperature and that causes the resonant frequencies to shift. This can be a large effect. Neither Selfridge nor Thompson has much information on the temperature coefficients of sound speeds.

The life of the material must also be considered as well as its overall strength. We have had customers design their own windows out of Kevlar. They required Kevlar because they required a material that was very strong both for temperature and for strength against heavy seas, objects in the water, and striking the bottom or ice. Kevlar can provide this strength without having to be very thick thus minimizing loss.

Kevlar windows have been successfully built and used by 2 different institutes (Monterey Bay Aquarium Research Institute (MBARI) in the United States, and the Institut National des Sciences de l'Univers (INSU) in France. The procedure to build the window is not known by TRDI. The properties of the Kevlar windows are not well understood and so a lot of experimentation with different thickness windows was required before these customers were satisfied with the Kevlar window.

INSU used a graduate student, Roche Frederic in 1997, to perform a study to determine the best thickness and composite of Kevlar to provide a window for a BB VM150kHz ADCP. The report states that the material KEVLAR K49 made with Resine Vinylester ATLAC 580 was used. The following French company produced this material:

Brest-Composite Industrie
124 Rue Auatole Frauce
29200 – Brest, France
Tel: 02-98-05-19-09
Fax: 02-98-34-06-02

TRDI only knows that this single window was produced for INSU and does not know of any others who are using this material. It is TRDI's understanding that the above-mentioned company can produce the Kevlar window but cannot give the acoustic properties required to determine the losses through the window. Contacting this company is done with the knowledge that RD Instruments is not recommending them, but only offering this as a source for the material.

What are the Acoustic Window Installation Considerations?

In "What Window should I use?," page 302, we provided the recommended window material and thickness. In this section we will provide installation recommendations. Installation of the window must be done properly so that the best performance is possible. The following discussion is broken into sections so that each point can be considered individually.

What should the Window Shape be?

The window should be smooth without cracks or deformities. Typically the window is round and of a diameter that is large enough to clear all four beams. To determine the proper diameter of the window see "Conceptual Transducer Well Design," page 320.

The acoustic window should be flat and parallel to the transducer mounting plate. This will result in a constant angle of 20 or 30 degrees (depending on the transducer beam angle) to the transducer on both the inside and outside window face.

Dome shaped windows have been used successfully. However, if the water temperatures inside the window and outside the window are not the same, all four beams will be refracted and actual velocity components will be rotated into a new coordinate system. In particular, some of the horizontal velocity will appear as a vertical velocity.

Can I Add Strengthening to the Window?

Adding a strengthening member across the window is not recommended because this can cause similar behavior as a cracked window (see "If I find that the Window is Damaged Can I Keep Operating the ADCP?," page 312) or can actually block the acoustic transmit and receive signals.

How do I Secure the Window to the Well Opening?

We recommend that a steel ring around the outside of the window be used because you do not want the screw heads to come in direct contact with the window material as it may crack under the strain.

It is recommended that the window be designed so that the ring will sit flush with the entire window face as shown in the Figure 62. Flat headed bolts or recessed bolts should be used. All of these will maintain a smooth surface around the entire window and will prevent any chance for cavitation (see "Do I Need to Worry About Air Bubbles When Using a Window? ," page 311 for more information).

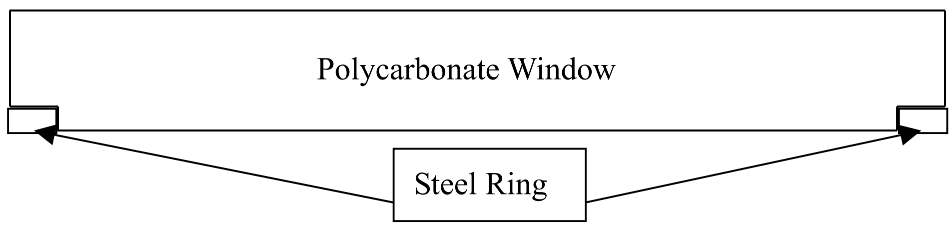


Figure 62. Conceptual Drawing of an Acoustic Window with Mounting Ring

Do not thread the polycarbonate window. Use bolt through holes spaced evenly around the window. The number of bolt through holes (typically 16 to 24 holes) should be enough to prevent leakage and will provide equal pressure on the window to prevent cracking.

The bolt circle should be located a distance from the edge of the window that is a minimum of twice the diameter of the bolt through holes, see Figure 63, page 308.

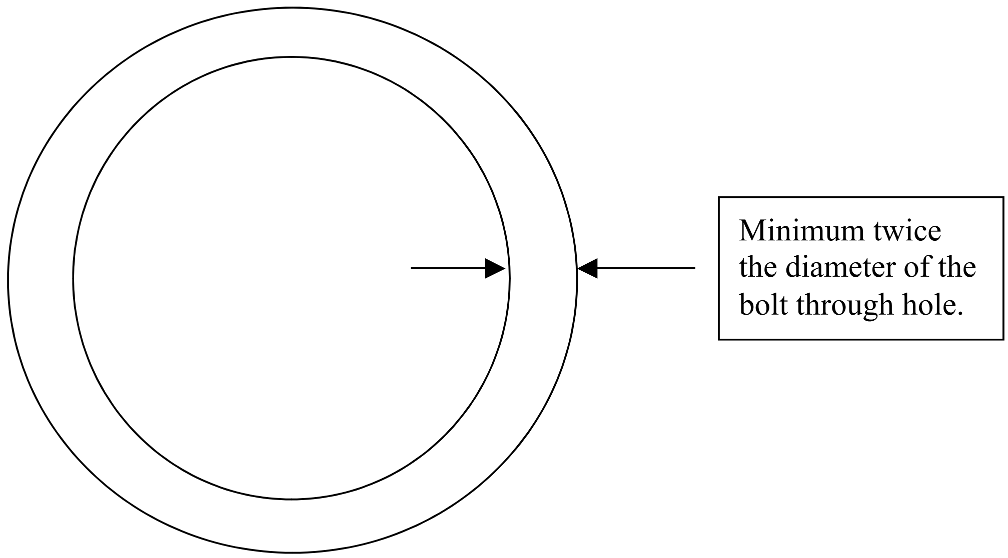


Figure 63. Location of the Window Bolt Hole Circle Diameter

How to Prevent the Window From Cracking When Going Into Dry Dock?

Using as thin a window as possible may mean that the window will not be able to support the water inside the sea chest when the vessel goes into dry dock. This means that you must either be sure to have a way to drain the sea chest prior to going into dry dock or allow a way for the water to drain out of the sea chest during dry dock. The former must be done as part of the sea chest design and the latter can be accomplished by placing holes in the window face.

The holes in the window face will allow water to freely flow in and out of the well. However, drilling holes in the window will increase your chances of flow noise, air bubbles in sea chest, corrosion, bio-fouling, and will make the sea chest non-hydrostatic. The bio-fouling will require that you have regular transducer inspections and cleanings. If you make the sea chest non-hydrostatic then in heavy seas the window can crack as it flexes from wave slamming. Dave Taylor Model Basin has measured slamming pressures as high as 300 psi with durations of a few milliseconds. If the sea chest behind the window is hydrostatic, no pressure gradient will exist across the window and no substantial deflections will occur.

With those considerations in mind you may still want to drill holes in the window. If you drill holes in the window then you must make sure that they are outside of the acoustic beam pattern of the beams, see Figure 64, page 309. As long as the holes remain outside of the beams they can be as large as is required to prevent the window from flexing when in heavy seas.

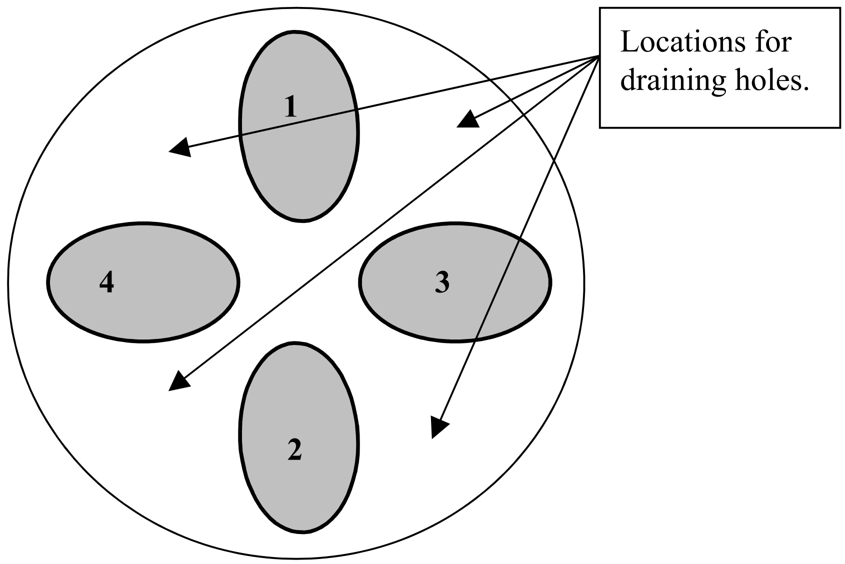


Figure 64. Draining holes locations around beams 1-4 intersection with the window.

How Much Space should I Have Between the Window and Transducer?

Never allow the transducer to touch the window. Separation is good for reducing the strength of the multiple fields of flow noise. However, we must limit the separation to prevent the reflection of a beam off of the window into another beam. This causes cross talk between the beams.

Therefore, with all ADCP models and frequencies the recommended distance between the transducer and the inside face of the window should be between 6.4mm to 12.7mm. This will ensure that there is no cross talk between beams and will provide adequate spacing to reduce flow noise. See "Conceptual Transducer Well Design," page 320 for more sea chest design issues.

What Other Issues should be Considered When Using an Acoustic Window?

Once you decide to use a window there are many issues that no longer are a worry but there other new things you do need to worry about. This section will outline each of these items and the issues related to them.

What Fluid Should I Fill the Sea Chest With?

If you have not placed holes in the window and you are not going to work in an area where freezing is an issue then the sea chest should be filled with fresh water. Fresh water decreases the issues of corrosion in the sea chest.

If you will be in an area where freezing of fresh water would be an issue then seawater can be used.

Some users have placed ethylene glycol into the fresh water well to prevent freezing. Although this will not harm the transducers you will have to perform post processing on the data sets from the NB, BB, and WH ADCPs (this issue is not present for the OS ADCP). The NB, BB, and WH ADCPs must have the velocity data scaled properly based on the speed of sound in the sea chest. Ethylene glycol causes the water to have an inverted speed of sound change to that of fresh water or salt water. This means that TRDI's standard software programs will not be scale the data properly. You will have to record separately the speed of sound in the sea chest and then in post processing correct the ADCP velocity data appropriately.

How Much Fluid Should I Use in the Sea Chest?

The transducers must be completely immersed in water. No air should be in front of the transducers and the pressure within the sea chest should be adjusted to keep the window from bowing in and out, and thereafter, the volume should be kept constant.

Should I Use Absorption Material When Using a Window?

The window causes some of the transmit signal to reflect back into the well due to the difference in impedance between the window and the water. When the transmit signal is reflected in the well it becomes trapped and this results in what is called ringing. To keep from processing this signal, the blanking of the ADCP will have to be increased.

However, in extreme cases, ringing can last a period that will cause the first 50-100 meters of data to be unusable. Therefore, a sound absorbing material should be used inside the sea chest to minimize the effects of sound ringing within the sea chest. The material should be a minimum of one wavelength thick (include the sound speed of the absorbing material when calculating the size of a wavelength). Approximate wavelengths of sound in seawater are given below. Using standard neoprene wet suit material has been found to work well with 75 and 150hKz frequency ADCPs.

Table 74: Wavelength of sound in seawater (1500 m/s sound speed)

Frequency (kHz)	Wavelength (mm)
38	40
75	20
150	10
300	5

Do I Need to Worry About Corrosion When Using a Window?

Corrosion is always possible. However, our transducers are made of a material that has shown to corrode very little over time when the above precautions are met. There is nothing that you can do to protect the transducer from corrosion. However, if the well is covered with a window and then filled with fresh water corrosion is can be further minimized. You should inspect the transducer regularly for signs of corrosion.

Note, never attach any anodes directly to the transducer head. Additional anodes or impressed voltage systems can cause the urethane to separate from the transducer (cathodic disbondment) or cause the material of the transducer to break down. Standard anode protection used for the ship should be installed outside of the well of the transducer head. Mounting of ship's standard anode protection outside of the transducer well will typically not cause any problems.

Do I Need to Worry About Air Bubbles When Using a Window?

All vessels create air bubbles in the water as the ship moves through the water. Ships with a deep draft or a non-flat bottom have fewer problems with bubbles. If you are using a window these bubbles will still be present. If the window is sealed then this air will not fill the sea chest. However, if the window is not sealed then air can fill the sea chest. You must make sure to vent air from the sea chest periodically if there is a possibility that air will become trapped in your sea chest.

To avoid air bubbles from getting into the front of the window you should mount the transducers below or away from the bubble layer. The flow layer is usually within the first two feet below the hull. Bubbles can be trapped in this layer. Mounting the transducer head amid ship on the fore-to-aft centerline may help. Another technique is to divert the bubble layer so it flows around the transducers. A fairing around the sea chest can help with this, but care must be taken so that you do not cause cavitation.

Do windows Improve Flow Noise Problems?

Water flowing over the transducer faces increases the acoustic noise level, which decreases the profiling range of the ADCP. A window reduces the coupling of flow noise to the transducer. This is because of the gap filled with fluid between the inside of the window face and the transducer faces attenuates the flow noise. By reducing flow noise you are increasing the signal to noise ratio. The higher the signal to noise ratio the better the stronger the returned signal will appear. This will result in better data reception and longer ranges.

What Maintenance is required when using Windows?

In general, a window provides protection to the transducer from the most common sources of problems such as bio fouling and corrosion. However, the window can still become covered with bio fouling or could become damaged. The following section discusses these issues.

How Often Should I Inspect the Window?

Since growth of mussels, barnacles, and other bio fouling occurs on all vessels the window should be inspected and cleaned by divers on a regular interval. This interval should be often enough to prevent the growth of anything on the window and to allow inspection for damage to the window. It is recommended that this interval be at least once per year, but may be required more often in areas that have heavy bio-fouling growth.

When inspecting the window you should inspect for bio-fouling growth, cracks, damage, for air pockets, and for mud on the inside of the window. We have seen cases where the inside of the well became filled with mud. The mud entered through a crack in the window and where the holes were drilled in the window. Bio fouling should be cleaned off, air should be purged from the sea chest, and mud should be removed from the sea chest.

If I find that the Window is Damaged Can I Keep Operating the ADCP?

In general, any window that is cracked or is damaged so that it is not smooth should be replaced as soon as possible.

A window that is damaged causes a problem with the acoustic transmission. The exact problem or problems seen because of this damage will vary depending on where the break is and the way a beam would strike the damage. All windows have losses because of an impedance difference to the water inside the well and outside the well. There are also losses that are built up in the window. An important loss is due to the shear wave that is created as our acoustic signal passes through the window at an angle. This shear wave traps sound in the thickness of the window as the acoustic signal tries to pass through the window. If the window has a crack in it then the window can cause this trapped energy to bounce in all directions rather than remain trapped in the window. Depending on the size of the crack, the location of the crack, and what the window does around the crack this reflected energy may even go into other beams.

Regrettably, there is no way to predict on what can happen as a crack will have a strange pattern to it. A single beam or all four beams may be affected. However, in either case it is enough to know that a crack in the window is very bad and will cause the energy that is transmitted and received in a beam to be deflected at strange angles.

Additionally, cracks can cause the window to have a rough surface. This can result in cavitation around the window. Cavitation results in air being trapped near the crack. This air can cause energy to be reflected back into the transducer well instead of traveling through the water.

Does the Use of a Window Effect My Warranty?

The use of a window has no impact on warranty. The window is primarily an aid to optimal performance. A window isolates the transducer face from flow noise when the vessel is moving and provides protection from bio fouling. These all increase the performance and reliability of the transducer. The window will also absorb some of the transmitted and returned signals. This will have an adverse effect on performance. However, when the proper window is used this adverse effect is minimal compared to the benefits of using a window. TRDI cannot be responsible for the acoustic design of the vessel, but that design and the installation of our transducer certainly can adversely affect the ADCP system performance.

Insertion Loss

The following section contains insertion (one-way) loss graphs for each of the ADCP frequencies at each transducer beam angle at 0°C. These graphs are provided as an example of the expected insertion loss.

The main beam of each ADCP system at its maximum bandwidth is displayed as the red line on each graph (the sin X/X is represented by the smaller bumps in red). The minimum and maximum frequencies used on the X-axis of the graph were chosen so that this bandwidth would be approximately centered on the graph.

The blue line represents the expected loss across this bandwidth of frequencies for this thickness of polycarbonate. The Y-axis of each graph represents the expected insertion loss. See the example below for descriptions.

Uniform Ave. IL represents the entire average insertion loss over the entire frequency (X-axis) shown. The Weighted Ave. IL represents the average insertion loss over the bandwidth of the ADCP frequency. The Weighted Ave. IL is used to complete Table 72, page 303 and Table 73, page 304 of this document.

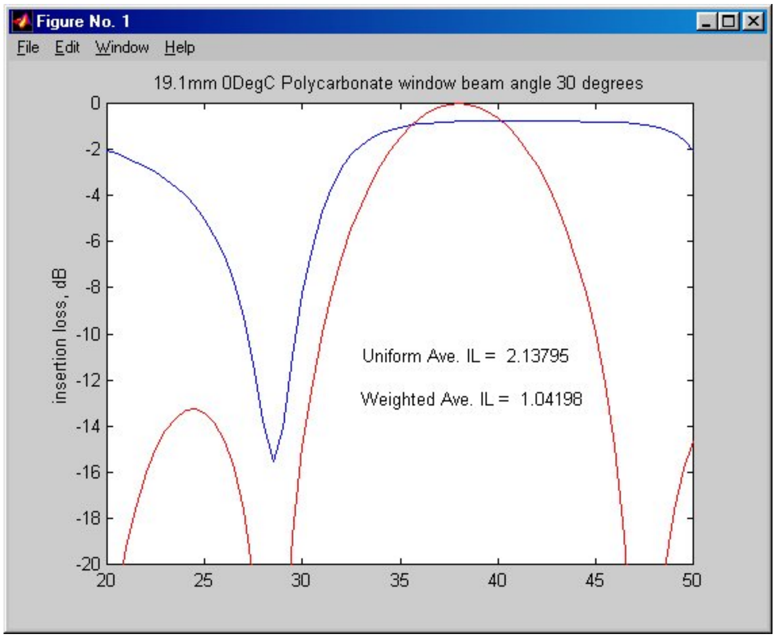


Figure 65. **38kHz Insertion Loss (one-way) with a 19.1mm window at 0°C**

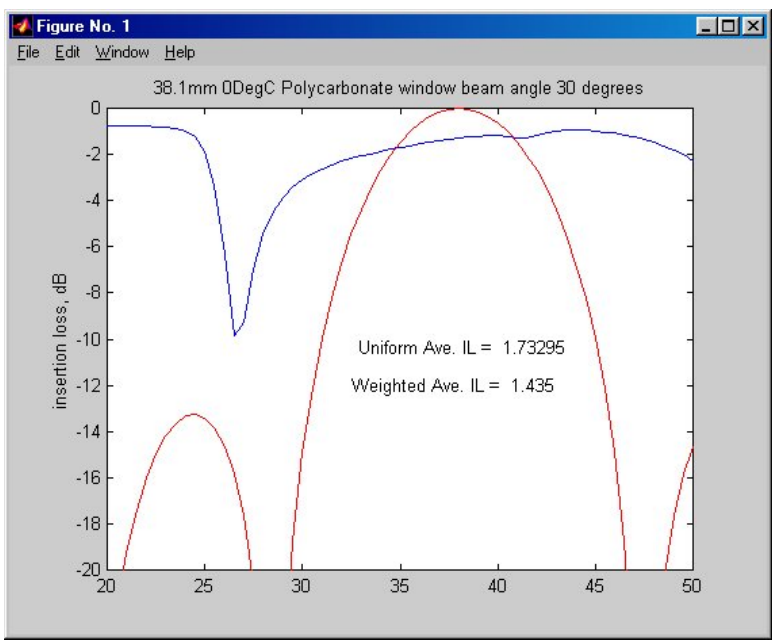


Figure 66. **38kHz Insertion Loss (one-way) with a 38.1mm window at 0°C**

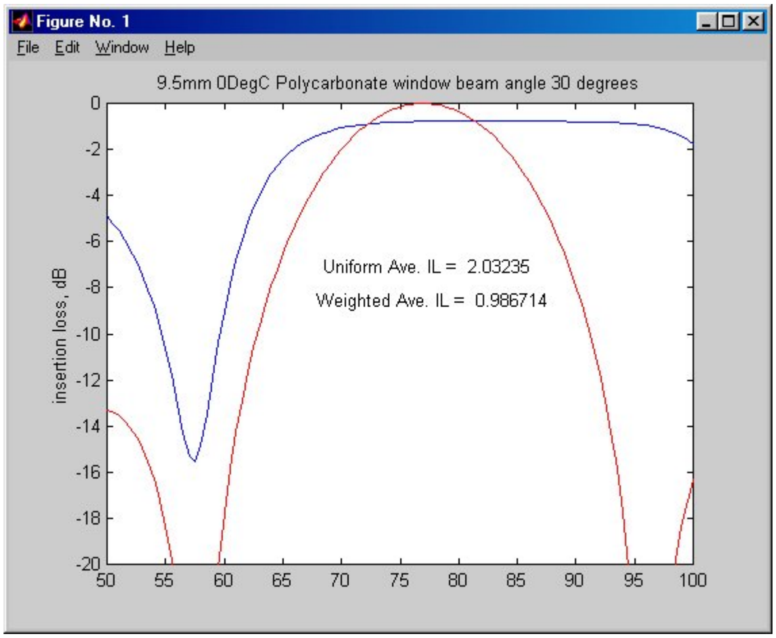


Figure 67. 75kHz Insertion Loss (one-way) with a 9.5mm window at 0°C

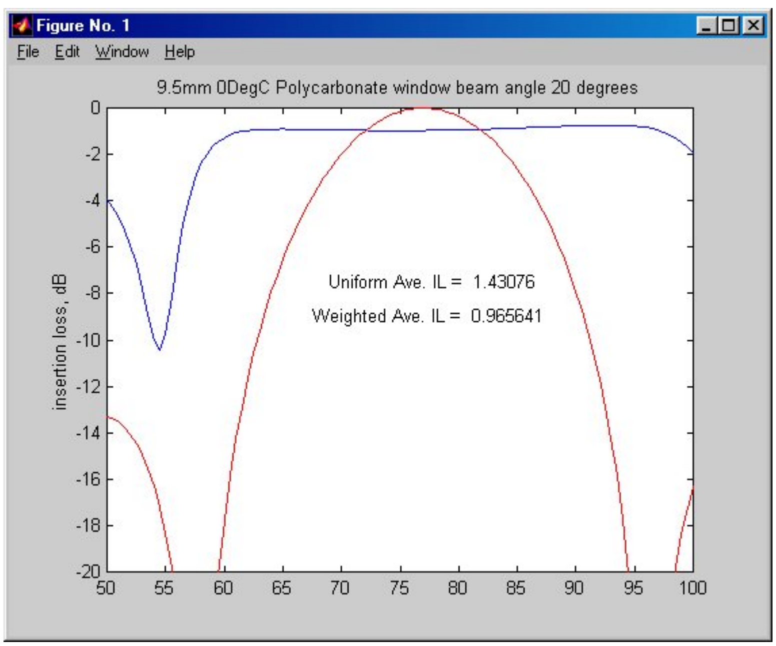


Figure 68. 75kHz Insertion Loss (one-way) with a 9.5mm window at 0°C

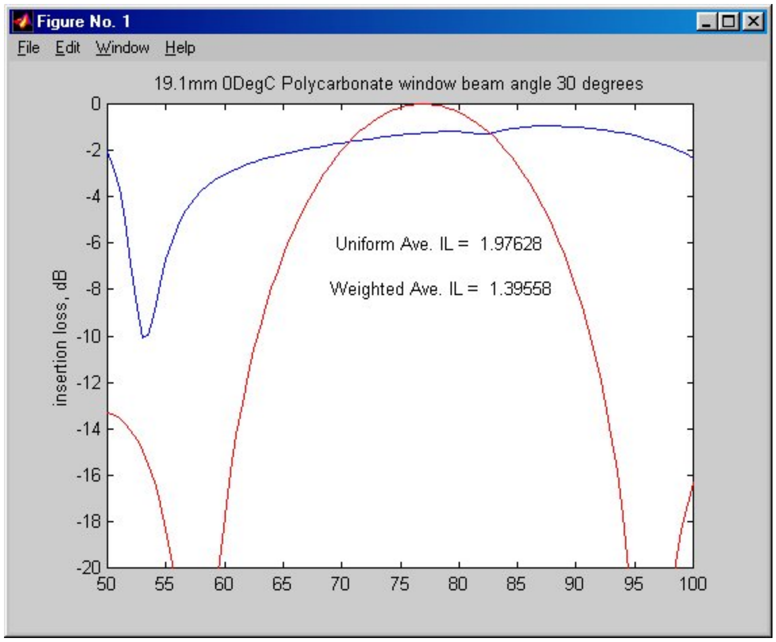


Figure 69. 75kHz Insertion Loss (one-way) with a 19.1mm window at 0°C

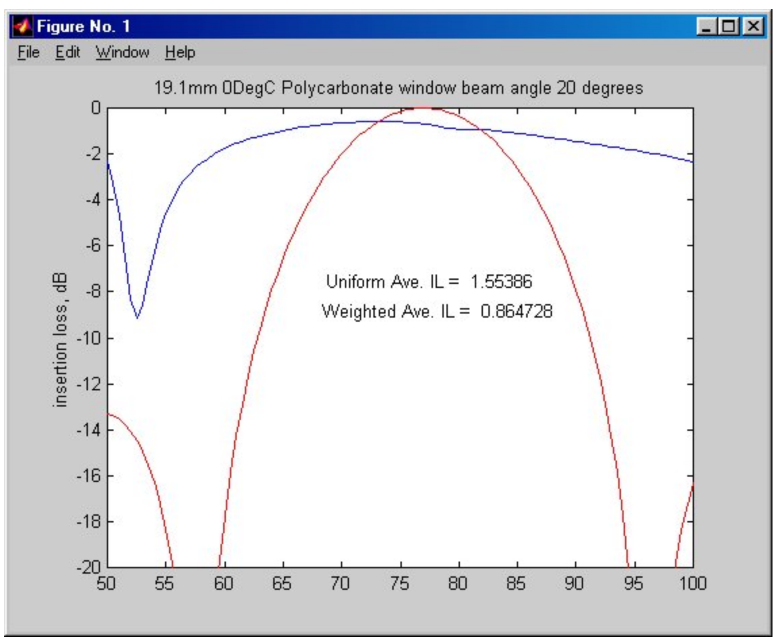


Figure 70. 75kHz Insertion Loss (one-way) with a 19.1mm window at 0°C

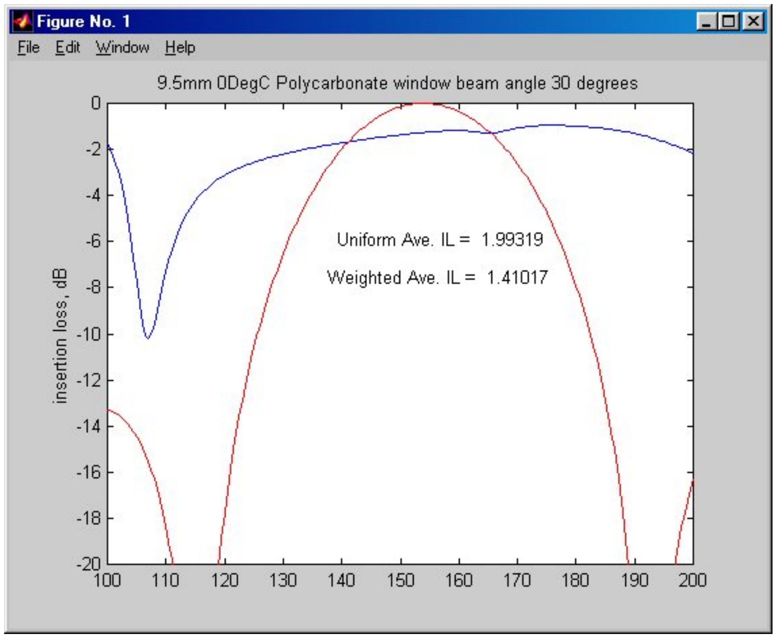


Figure 71. 150kHz Insertion Loss (one-way) with a 9.5mm window at 0°C

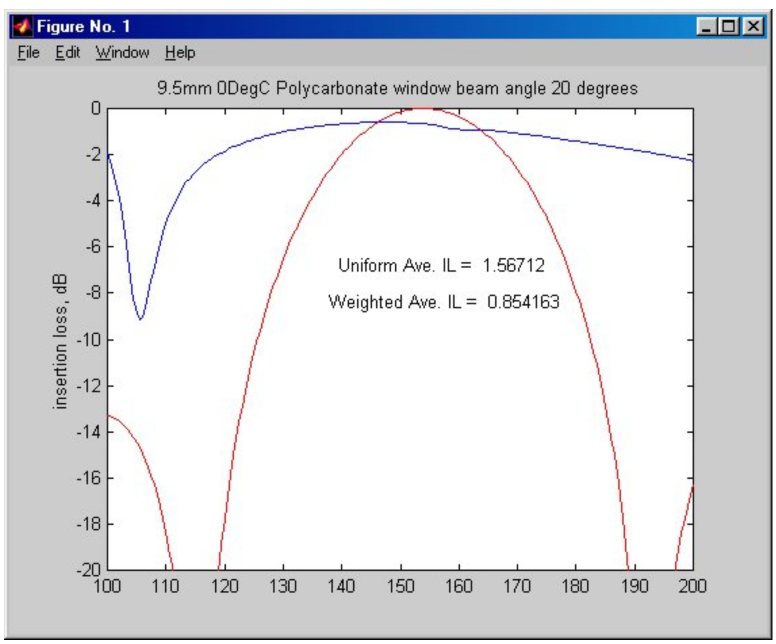


Figure 72. 150kHz Insertion Loss (one-way) with a 9.5mm window at 0°C

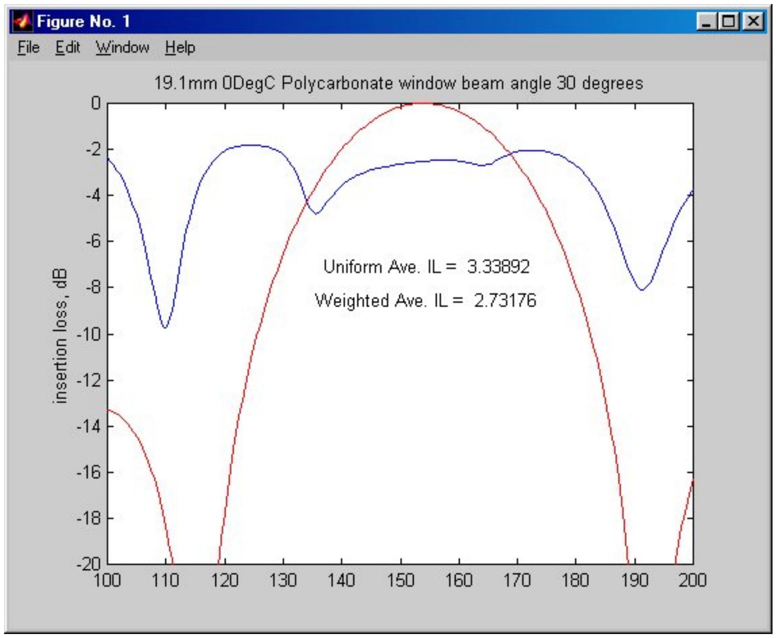


Figure 73. 150kHz Insertion Loss (one-way) with a 19.1mm window at 0°C

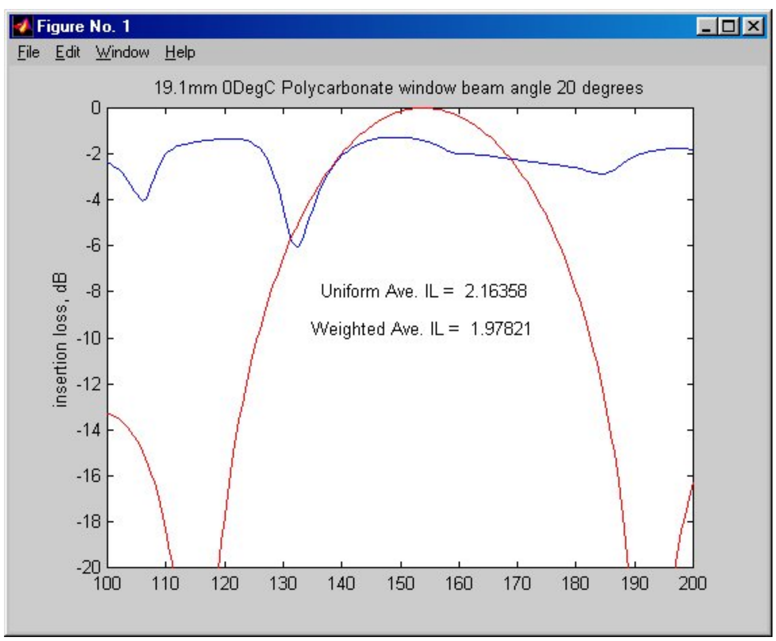


Figure 74. 150kHz Insertion Loss (one-way) with a 19.1mm window at 0°C

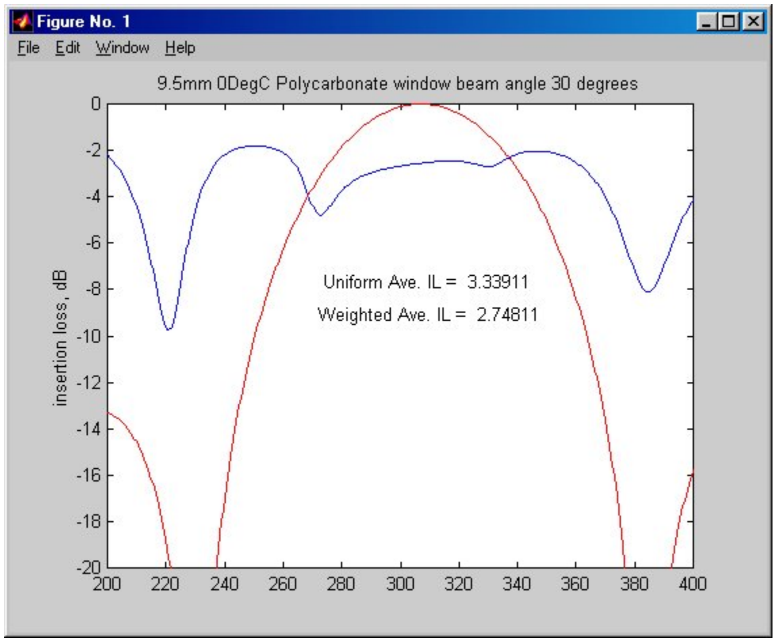


Figure 75. 300kHz Insertion Loss (one-way) with a 9.5mm window at 0°C

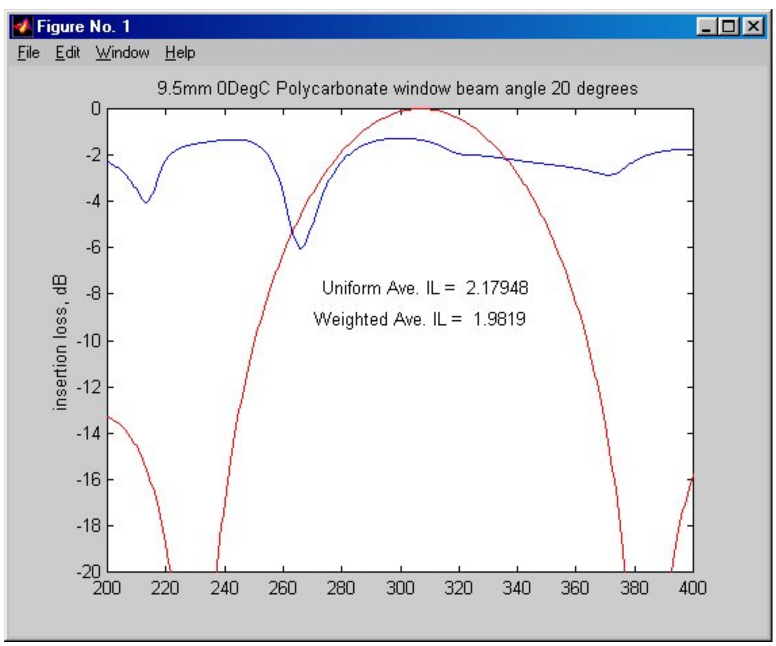


Figure 76. 300kHz Insertion Loss (one-way) with a 9.5mm window at 0°C

Conceptual Transducer Well Design

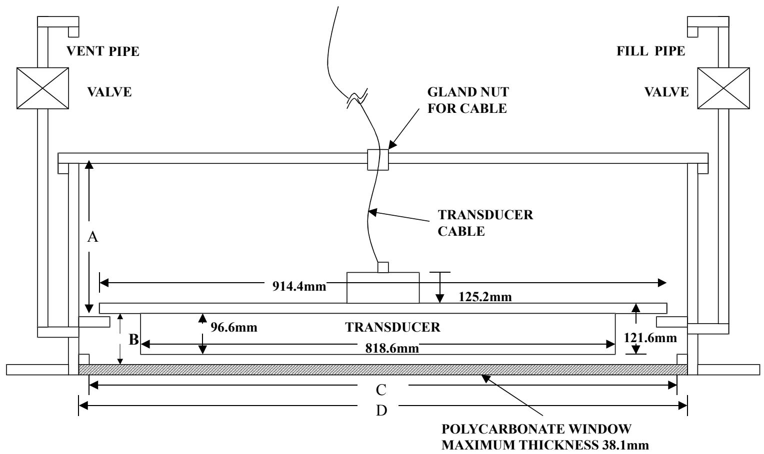


Figure 77. Inside Vessel Mounting - OS 38khz Transducer

Dimension Letter	Option 1 Minimum Dimension	Option 2 Maximum Dimension
A	384mm	738mm
B	103.0mm	109.5m
C	908mm	921mm
D	1010mm	1023mm

Special Notes:

a. No liability is assumed by RD Instruments for users using this conceptual well drawing. Users realize that this drawing is provided as a basis for the user to construct their own well. It is expected that the user will have their well design inspected and approved by a naval architect.

b. The top plate of the well is intended as the primary seal for the vessel. The window and transducer can provide additional seal but should not be considered the primary sealing mechanism for the vessel.

c. This conceptual well drawing is designed such that it would be possible to remove the transducer from inside the vessel. For safety, it is strongly recommended that divers fit a steel plate either over the window or in place of the window before installing or removing the transducer.

d. The listed minimum and maximum dimensions are recommendations based on maintaining the clearance for the transducer as well as providing the smallest well possible.

e. The gasket material between the transducer housing and the vessel flange should be used that will both seal and provide electrical isolation between the transducer housing and the vessel flange. Typical gasket material used is silicone rubber 3-6.35mm thick.

f. Inserts in the transducer housing mounting holes may be used to provide additional isolation from vessel.

g. The walls of the well should be coated with a material to absorb reflected sound in the well. Material such as 3mm wet suit material glued to the inside well walls is satisfactory for this purpose.

h. Vent and fill pipes should be above the water line of the vessel and it is recommended that a gate valve be installed to seal off these pipes.

i. Window thickness should not exceed 38.1 mm of Polycarbonate material. Thinner Polycarbonate window is OK.

j. Window faces should be parallel to the transducer face to within 2 degree for best performance; angle should never exceed 5 degrees.

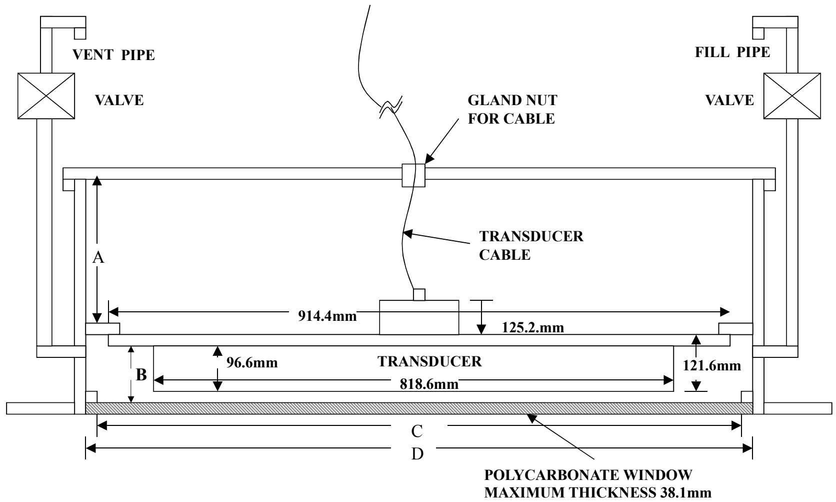


Figure 78. Underneath Vessel Mounting - OS 38khz Transducer

Dimension Letter	Option 1 Minimum Dimension	Option 2 Maximum Dimension
A	384mm	738mm
B	103.0mm	109.5m
C	1016mm	1016mm
D	1118mm	1118mm

Special Notes:

a. No liability is assumed by RD Instruments for users using this conceptual well drawing. Users realize that this drawing is provided as a basis for the user to construct their own well. It is expected that the user will have their well design inspected and approved by a naval architect.

b. The top plate of the well is intended as the primary seal for the vessel. The window and transducer can provide additional seal but should not be considered the primary sealing mechanism for the vessel.

c. This conceptual well drawing is designed such that it would be possible to remove the transducer from inside the vessel. For safety, it is strongly recommended that divers fit a steel plate either over the window or in place of the window before installing or removing the transducer.

d. The listed minimum and maximum dimensions are recommendations based on maintaining the clearance for the transducer as well as providing the smallest well possible.

e. The gasket material between the transducer housing and the vessel flange should be used that will both seal and provide electrical isolation between the transducer housing and the vessel flange. Typical gasket material used is silicone rubber 3-6.35mm thick.

f. Inserts in the transducer housing mounting holes may be used to provide additional isolation from vessel.

g. The walls of the well should be coated with a material to absorb reflected sound in the well. Material such as 3mm wet suit material glued to the inside well walls is satisfactory for this purpose.

h. Vent and fill pipes should be above the water line of the vessel and it is recommended that a gate valve be installed to seal off these pipes.

i. Window thickness should not exceed 38.1 mm of Polycarbonate material. Thinner Polycarbonate window is OK.

j. Window faces should be parallel to the transducer face to within 2 degree for best performance; angle should never exceed 5 degrees.

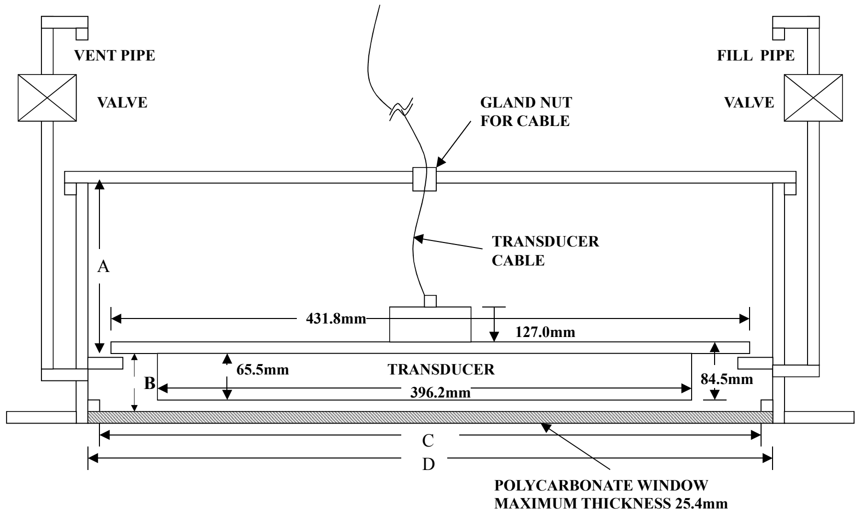


Figure 79. Inside Vessel Mounting - OS 75khz Transducer

Dimension Letter	Option 1 Minimum Dimension	Option 2 Maximum Dimension
A	384mm	738mm
B	71.9mm	78.2mm
C	461mm	474mm
D	563mm	576mm

Special Notes:

a. No liability is assumed by RD Instruments for users using this conceptual well drawing. Users realize that this drawing is provided as a basis for the user to construct their own well. It is expected that the user will have their well design inspected and approved by a naval architect.

b. The top plate of the well is intended as the primary seal for the vessel. The window and transducer can provide additional seal but should not be considered the primary sealing mechanism for the vessel.

c. This conceptual well drawing is designed such that it would be possible to remove the transducer from inside the vessel. For safety, it is strongly recommended that divers fit a steel plate either over the window or in place of the window before installing or removing the transducer.

d. The listed minimum and maximum dimensions are recommendations based on maintaining the clearance for the transducer as well as providing the smallest well possible.

e. The gasket material between the transducer housing and the vessel flange should be used that will both seal and provide electrical isolation between the transducer housing and the vessel flange. Typical gasket material used is silicone rubber 3-6.35mm thick.

f. Inserts in the transducer housing mounting holes may be used to provide additional isolation from vessel.

g. The walls of the well should be coated with a material to absorb reflected sound in the well. Material such as 3mm wet suit material glued to the inside well walls is satisfactory for this purpose.

h. Vent and fill pipes should be above the water line of the vessel and it is recommended that a gate valve be installed to seal off these pipes.

i. Window thickness should not exceed 25.4 mm of Polycarbonate material. Thinner Polycarbonate window is OK.

j. Window faces should be parallel to the transducer face to within 2 degree for best performance; angle should never exceed 5 degrees.

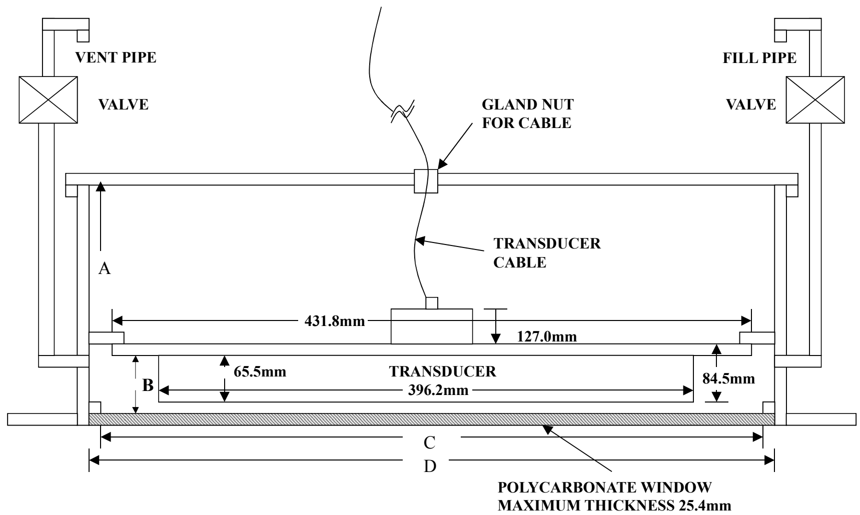


Figure 80. Underneath Vessel Mounting - OS 75khz Transducer

Dimension Letter	Option 1 Minimum Dimension	Option 2 Maximum Dimension
A	384mm	738mm
B	71.9mm	78.2mm
C	533.4mm	533.4mm
D	635mm	635mm

Special Notes:

a. No liability is assumed by RD Instruments for users using this conceptual well drawing. Users realize that this drawing is provided as a basis for the user to construct their own well. It is expected that the user will have their well design inspected and approved by a naval architect.

b. The top plate of the well is intended as the primary seal for the vessel. The window and transducer can provide additional seal but should not be considered the primary sealing mechanism for the vessel.

c. This conceptual well drawing is designed such that it would be possible to remove the transducer from inside the vessel. For safety, it is strongly recommended that divers fit a steel plate either over the window or in place of the window before installing or removing the transducer.

d. The listed minimum and maximum dimensions are recommendations based on maintaining the clearance for the transducer as well as providing the smallest well possible.

e. The gasket material between the transducer housing and the vessel flange should be used that will both seal and provide electrical isolation between the transducer housing and the vessel flange. Typical gasket material used is silicone rubber 3-6.35mm thick.

f. Inserts in the transducer housing mounting holes may be used to provide additional isolation from vessel.

g. The walls of the well should be coated with a material to absorb reflected sound in the well. Material such as 3mm wet suit material glued to the inside well walls is satisfactory for this purpose.

h. Vent and fill pipes should be above the water line of the vessel and it is recommended that a gate valve be installed to seal off these pipes.

i. Window thickness should not exceed 25.4 mm of Polycarbonate material. Thinner Polycarbonate window is OK.

j. Window faces should be parallel to the transducer face to within 2 degree for best performance; angle should never exceed 5 degrees.

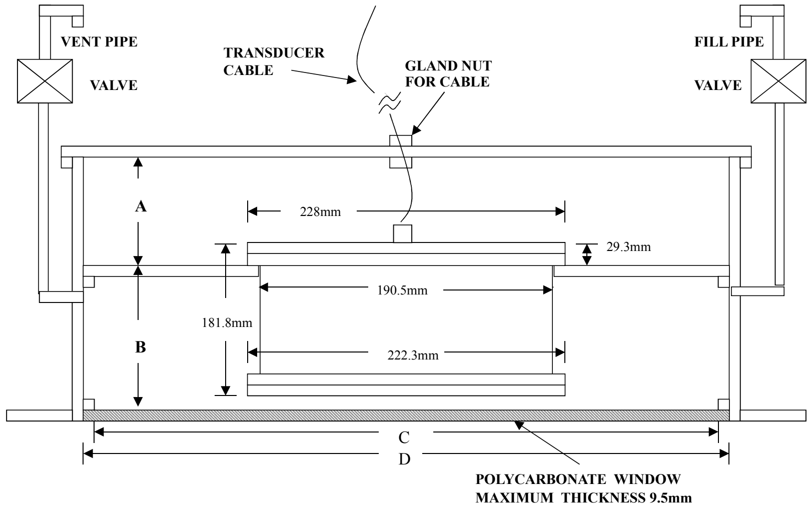


Figure 81. Inside Vessel Mounting - OS 150khz Transducer

Dimension Letter	Option 1 Minimum Dimension	Option 2 Maximum Dimension
A	220mm	400mm
B	158.9mm	165.2mm
C	255mm	268mm
D	356.6mm	369.6mm

Special Notes:

a. No liability is assumed by RD Instruments for users using this conceptual well drawing. Users realize that this drawing is provided as a basis for the user to construct their own well. It is expected that the user will have their well design inspected and approved by a naval architect.

b. The top plate of the well is intended as the primary seal for the vessel. The window and transducer can provide additional seal but should not be considered the primary sealing mechanism for the vessel.

c. This conceptual well drawing is designed such that it would be possible to remove the transducer from inside the vessel. For safety, it is strongly recommended that divers fit a steel plate either over the window or in place of the window before installing or removing the transducer.

d. The listed minimum and maximum dimensions are recommendations based on maintaining the clearance for the transducer as well as providing the smallest well possible.

e. The gasket material between the transducer housing and the vessel flange should be used that will both seal and provide electrical isolation between the transducer housing and the vessel flange. Typical gasket material used is silicone rubber 3-6.35mm thick.

f. Inserts in the transducer housing mounting holes may be used to provide additional isolation from vessel.

g. The walls of the well should be coated with a material to absorb reflected sound in the well. Material such as 3mm wet suit material glued to the inside well walls is satisfactory for this purpose.

h. Vent and fill pipes should be above the water line of the vessel and it is recommended that a gate valve be installed to seal off these pipes.

i. Window thickness should not exceed 9.5 mm of Polycarbonate material. Thinner Polycarbonate window is OK.

j. Window faces should be parallel to the transducer face to within 2 degree for best performance; angle should never exceed 5 degrees.

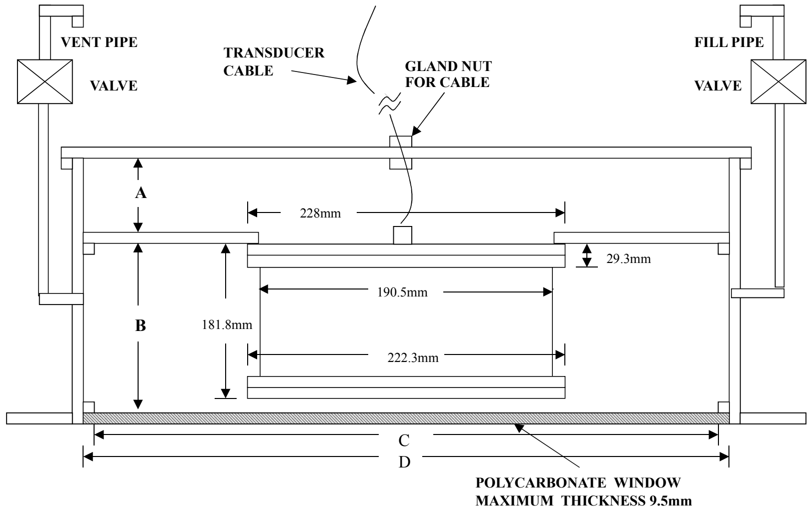


Figure 82. Underneath Vessel Mounting - OS 150khz Transducer

Dimension Letter	Option 1 Minimum Dimension	Option 2 Maximum Dimension
A	195mm	375mm
B	188.2mm	194.5mm
C	324.6mm	324.6mm
D	426.2mm	426.2mm

Special Notes:

a. No liability is assumed by RD Instruments for users using this conceptual well drawing. Users realize that this drawing is provided as a basis for the user to construct their own well. It is expected that the user will have their well design inspected and approved by a naval architect.

b. The top plate of the well is intended as the primary seal for the vessel. The window and transducer can provide additional seal but should not be considered the primary sealing mechanism for the vessel.

c. This conceptual well drawing is designed such that it would be possible to remove the transducer from inside the vessel. For safety, it is strongly recommended that divers fit a steel plate either over the window or in place of the window before installing or removing the transducer.

d. The listed minimum and maximum dimensions are recommendations based on maintaining the clearance for the transducer as well as providing the smallest well possible.

e. The gasket material between the transducer housing and the vessel flange should be used that will both seal and provide electrical isolation between the transducer housing and the vessel flange. Typical gasket material used is silicone rubber 3-6.35mm thick.

f. Inserts in the transducer housing mounting holes may be used to provide additional isolation from vessel.

g. The walls of the well should be coated with a material to absorb reflected sound in the well. Material such as 3mm wet suit material glued to the inside well walls is satisfactory for this purpose.

h. Vent and fill pipes should be above the water line of the vessel and it is recommended that a gate valve be installed to seal off these pipes.

i. Window thickness should not exceed 9.5 mm of Polycarbonate material. Thinner Polycarbonate window is OK.

j. Window faces should be parallel to the transducer face to within 2 degree for best performance; angle should never exceed 5 degrees.

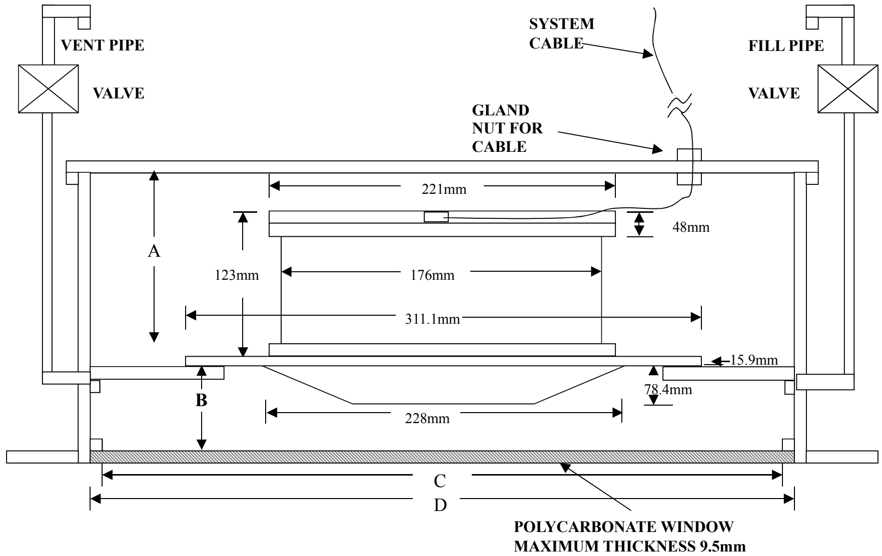


Figure 83. Inside Vessel Mounting - WH Mariner 300khz Transducer

Dimension Letter	Option 1 Minimum Dimension	Option 2 Maximum Dimension
A	275.4mm	275.4mm
B	84.7mm	91.1mm
C	362mm	362mm
D	412mm	412mm

Special Notes:

a. No liability is assumed by RD Instruments for users using this conceptual well drawing. Users realize that this drawing is provided as a basis for the user to construct their own well. It is expected that the user will have their well design inspected and approved by a naval architect.

b. The top plate of the well is intended as the primary seal for the vessel. The window and transducer can provide additional seal but should not be considered the primary sealing mechanism for the vessel.

c. This conceptual well drawing is designed such that it would be possible to remove the transducer from inside the vessel. For safety, it is strongly recommended that divers fit a steel plate either over the window or in place of the window before installing or removing the transducer.

d. The listed minimum and maximum dimensions are recommendations based on maintaining the clearance for the transducer as well as providing the smallest well possible.

e. The gasket material between the transducer housing and the vessel flange should be used that will both seal and provide electrical isolation between the transducer housing and the vessel flange. Typical gasket material used is silicone rubber 3-6.35mm thick.

f. Inserts in the transducer housing mounting holes may be used to provide additional isolation from vessel.

g. The walls of the well should be coated with a material to absorb reflected sound in the well. Material such as 3mm wet suit material glued to the inside well walls is satisfactory for this purpose.

h. Vent and fill pipes should be above the water line of the vessel and it is recommended that a gate valve be installed to seal off these pipes.

i. Window thickness should not exceed 9.5 mm of Polycarbonate material. Thinner Polycarbonate window is OK.

j. Window faces should be at an angle of 20 degrees +/-2 degrees to all of the transducer faces degree for best performance; angle should never exceed +/-5 degrees.

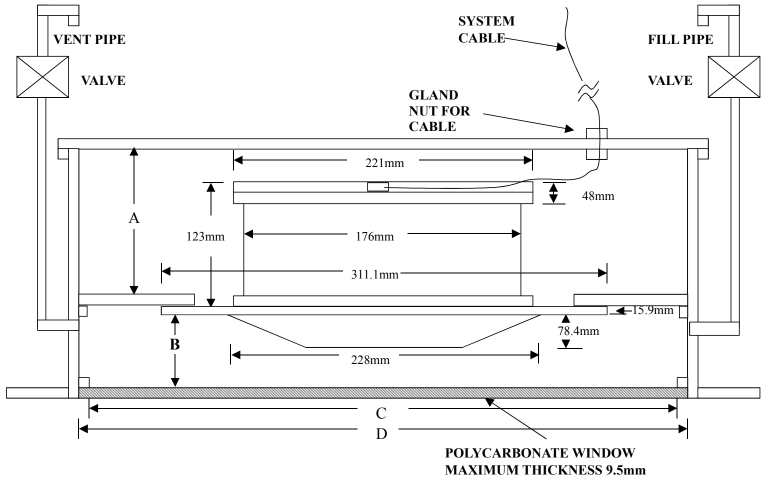


Figure 84. Underneath Vessel Mounting - WH Mariner 300khz Transducer

Dimension Letter	Option 1 Minimum Dimension	Option 2 Maximum Dimension
A	275.4mm	275.4mm
B	84.7mm	91.1mm
C	362mm	362mm
D	412mm	412mm

***Special Notes*:**

a. No liability is assumed by RD Instruments for users using this conceptual well drawing. Users realize that this drawing is provided as a basis for the user to construct their own well. It is expected that the user will have their well design inspected and approved by a naval architect.

b. The top plate of the well is intended as the primary seal for the vessel. The window and transducer can provide additional seal but should not be considered the primary sealing mechanism for the vessel.

c. This conceptual well drawing is designed such that it would be possible to remove the transducer from inside the vessel. For safety, it is strongly recommended that divers fit a steel plate either over the window or in place of the window before installing or removing the transducer.

d. The listed minimum and maximum dimensions are recommendations based on maintaining the clearance for the transducer as well as providing the smallest well possible.

e. The gasket material between the transducer housing and the vessel flange should be used that will both seal and provide electrical isolation between the transducer housing and the vessel flange. Typical gasket material used is silicone rubber 3-6.35mm thick.

f. Inserts in the transducer housing mounting holes may be used to provide additional isolation from vessel.

g. The walls of the well should be coated with a material to absorb reflected sound in the well. Material such as 3mm wet suit material glued to the inside well walls is satisfactory for this purpose.

h. Vent and fill pipes should be above the water line of the vessel and it is recommended that a gate valve be installed to seal off these pipes.

i. Window thickness should not exceed 9.5 mm of Polycarbonate material. Thinner Polycarbonate window is OK.

j. Window faces should be at an angle of 20 degrees +/-2 degrees to all of the transducer faces degree for best performance; angle should never exceed +/-5 degrees.

FSA-012 - Configuring Bottom Mode 6

Introduction

This application note is meant to assist in the configuration of Bottom Mode 6. Bottom Mode 6 is a very simple mode. There is no ambiguity resolving, which allows Bottom Mode 6 to operate in Narrower Bandwidths than the standard bottom tracking.

NOTE. Bottom Mode 6 is available for Navigator ADCP/DVLs only.

Benefits

Bottom Mode 6 has one benefit, Reduced Bandwidths. Bottom Mode 6 operates in 12.5% and 6.25% Bandwidths. The need for reduced bandwidth could arise to reduce interference or detectability.

Drawbacks

Bottom Mode 6, by reducing bandwidth, also reduces sample rate. This results in noisier data. Along with noisy data, comes the complexity of properly configuring the mode. Improper configuration can result in wild (unreasonable) data.

Background

Ambiguity Velocity

The ADCP calculates velocity from a phase measurement. The problem with a phase measurement is that the range is limited to 0° to 360°; thus 40° and 400° cannot be differentiated. The ambiguity velocity (Ua) is equivalent to limiting the phase measurement to +/- 180°. If the velocity is greater than the ambiguity velocity, it wraps around; i.e. if Ua = 180 cm/s, and the vessel velocity is 200 cm/s, the measured velocity is –160 cm/s. This is referred to as an ambiguity error. For further discussion of Phase Measurement and Ambiguity, consult the "ADCP Principles of Operation: A Practical Primer 2nd Edition for Broadband ADCPs". Keeping track of whether and how many times the ambiguity velocity has been exceeded is called Ambiguity Resolution. Ambiguity Resolution is not implemented in Bottom Mode 6.

Ambiguity Lane

An ambiguity lane is a manual ambiguity resolver. By making some assumptions about the conditions the ADCP will be used in, the processing algorithms can offset the zero angle to reduce the probability of an ambiguity error.

Setup

Before attempting to configure the system the following information must be available.

ADCP Installation

Janus angle

ADCP Alignment Angle

Approximate Range of Vessel Velocity

Desired Bandwidth

Tolerance for Noise

Bandwidth and Code Length are used to determine the ambiguity velocity via the following equation:

$$Uab = \frac{1500 m/s}{Ns \cdot CPE \cdot EL}$$

Where

Uab	= Ambiguity Velocity Radially along the beam
Ns	= Number of Samples per Element (Always 4)
CPE	= Carrier Cycles Per Element (8 = 12.5% BW, 16 = 6.25% BW)
EL	= Code Length in elements (7, 15, 31, and 63)

Use the following steps to help solve the equation.

Step 1 – Determine the Ambiguity Lane Center

The Ambiguity Lane Center is the average of the limits of the range of velocities.

$$\frac{MinVelocity + MaxVelocity}{2} = Ambiguity\ Lane\ Center$$

For example, if the vessel was expected to travel forward at 14 m/s and backwards at 2 m/s, the limits would be –2 m/s and 14 m/s, and the average would be 6 m/s. Therefore the Ambiguity Lane Center is 6 m/s.

Step 2 - Determine the Vessel's Ambiguity (Uav)

The range also determines the ambiguity velocity.

$$Upper\ Limit - Ambiguity\ Lane\ Center = Uav$$

Taking the example from above; the vessel's ambiguity velocity is the upper limit (14 m/s) minus the lane center (6 m/s); or 8 m/s.

Step 3 – Determine Radial Ambiguity Velocity Along the Beam (Uab)

Given the vessel's ambiguity (*Uav*) of 8 m/s, that needs to get converted to beam radial. That is achieved using sin() and cos() functions:

$$Uab = Uav \cdot \sin(JA) \cdot \cos(EA)$$

Where

JA = Janus Angle (WorkHorse = 20°, Navigator = 30°)

EA = Alignment Angle.

Make sure that the EA command setting reflects the correct alignment angle for the ADCP installation. If the ADCP is aligned with the ship (beam three is forward), EA will be zero. If the ADCP has been rotated 45° Starboard, EA will be 4500. For this example, use 45°.

Continuing with the example above, given Uav = 8 m/s;

$$Uab = 8m/s \cdot \sin(30°) \cdot \cos(45°) = 2.828m/s$$

Step 4 – Determine the Code Length (EL)

Since Bandwidth is assumed to be pre-determined, that leaves only the Code Length to be selected. The Code Length must be 7, 15, 31, or 63. To calculate the largest possible code for the given *Uab*, use the following equation:

$$EL(CPE, Uab) \leq \frac{1500m/s}{4 \cdot CPE \cdot Uab}$$

Finishing the example for 12.5% and 6.25% Bandwidths, the appropriate code lengths are

$$EL(8, 2.828) \leq \frac{1500m/s}{4 \cdot 8 \cdot 2.828m.s} \leq 16.575$$

$$EL(16, 2.828) \leq \frac{1500m/s}{4 \cdot 16 \cdot 2.828} \leq 8.288.$$

So for the 12.5% BW (8 Carrier Cycles per Element) case, the appropriate Code Length is less than or equal to 16.575. The final result is 15, since 15 is less than 16.575 and greater than 7. The 6.25% BW, (16 Carrier Cycles per Element) case results in a Code Length of 7.

Step 5 – Determine the BH Command Format

The BH Command is the primary configuration command for Bottom Mode 6. The BH command expects three comma-separated values to set the bandwidth, code length, and Ambiguity Lane Center.

The Bandwidth is either 1 or 3 (1 = 6.25% and 3 = 12.5%).

The code length is entered as 0 to 3 (0 = 7, 1 = 15, 2 = 31, and 3 = 63).

The Lane Center or Vessels Ambiguity Velocity (*Uav*) is entered in cm/s and the range is limited to 0 to 1800 cm/s.

So for the given examples of 12.5% and 6.25% bandwidths, the following BH commands would be sent to the unit.

BH 3, 1, 600 (12.5% BW)

BH 1,0,600 (6.25% BW)

Commands Used for Bottom Mode 6

BG – BM6 Transmit Restriction

Purpose: This command, if enabled, limits transmit to a specified pulse length or a percentage of the depth, whichever is shorter.

Format: BG x,yy,zzz

Range: x = Enable/Disable Transmit Restriction (0 = Restriction off; 1 = Restriction On)

yy = Percent of Depth to Transmit (0 – 50%)

zzz = Transmit Limitation in milliseconds (0 = Frequency Dependent Maximum)

1200kHz – 3 ms
600kHz – 9 ms
300kHz – 50 ms
150kHz – 100 ms

Default: BG 0,30,0

Recommended Setting. The default setting for this command is recommended for most applications.

Description: This command limits the length of transmit when using Bottom Mode 6 only. If transmit is not being limited (x=0), the unit will transmit yy% of the depth. If transmit is being limited (x=1), the unit will transmit the shorter of yy% of the depth or zzz milliseconds.

BH – BM6 Configuration

Purpose	This configures the following parameters of Bottom Mode 6: Bandwidth, Code Length, and Expected Velocity
Format	BH x,y,zzzz
Range	x = Bandwidth (1 = 6.25%; 3 = 12.5%)
	y = Code Length (0 = 7, 1 = 15, 2 = 31, 3 = 63)
	zzzz = Lane Center [cm/s] (0 – 1800 cm/s)
Default	BH 3,0,0

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description	The command allows only Bottom Mode 6 to be setup for Low Bandwidth Applications.

FSA-015 - Shallow Water Bottom Tracking Bottom Mode 7

Introduction

Shallow Water Bottom Tracking Mode 7 improves the performance envelope of our standard bottom tracking. A 1200 KHz ZedHed™ system will work in water as shallow as 30 cm. Bottom Mode 7 has an improved bottom location algorithm that improves performance in all locations and specifically in high backscatter environments. While its main improvement has been in shallow water performance, it can be used to the full range of the instrument.

Recommended Applications

Current profiling and discharge measurements in shallow rivers and streams.

Basic Operation

When Bottom Tracking is enabled (BP1 or more) the WorkHorse transmits pulses that are dedicated to determining the velocity of the WorkHorse relative to the bottom. The bottom pings are interleaved with the water pings with a separation determined by the TP command (Time Between Pings). As with Bottom Mode 5 a Bottom Track Ping actually consists of several pings with computations to determine the best velocity measurement for the depth and speed. The highest precision is obtained in depths less than 5 meters and velocities less than 90 cm/sec. When operating in shallow water the slower the velocity of the boat or float the more precise the velocity measurement.

The Bottom Track mode is by default Bottom Mode 5 (BM5). By enabling Bottom Mode 7 (BM7), you are able to improve your Bottom Track data in high backscatter environments such as rivers and improve shallow water performance.

What is Required

Update the WorkHorse ADCP firmware version to 16.19 (Monitor/Sentinel) and 10.12 (Rio Grande), or higher.

Install the Shallow Water Bottom Tracking Mode 7 feature upgrade in your WorkHorse ADCP.

Add the BM7 and &R30 command to your existing configuration command files to take advantage of this new mode.

Commands Relevant to Shallow Water Bottom Tracking

BP1	Enables Bottom Tracking

BM7	Selects Bottom Mode 7
BX80	Selects the maximum range for bottom detection. This can be adjusted to improve the time taken for bottom relocation in poor conditions in shallow water. The default for a 1200KHz ZedHed™ system is BX300 (30 meters). When debris or other factors are causing bottom tracking to be lost, the BX value can be reduced e.g. BX80 (8 meters). This will reduce the time for bottom relocation.
BV aaaaa,bbb,cc	This command adjusts the characteristics of Bottom Mode 7 and should be left at frequency dependant defaults. It should only be changed on the recommendation of RD Instruments Customer Service. Please refer to the WorkHorse Commands and Output Data Format guide for more details.
&R30	Adjusts the transmit pulse length to 30% of depth. This command MUST be used in conjunction with BM7. Also see section "other considerations".

Environmental Limits

Minimum Tracking depth for 1200KHz – 30cm

Bottom Mode 7 is currently not recommended for 600KHz systems.

Maximum horizontal velocity measurement is ±9m/sec.

Long term Accuracy is 0.3% velocity measurement ±0.1cm/s

Other Considerations:

Ping times for Shallow Water Bottom Tracking (Bottom Mode 7) are approximately 3 times longer than standard bottom tracking (Bottom Mode 5) in shallow water and approx. 1.5 times in water > 5m. If it is necessary to collect data as fast as possible, Bottom Mode 5 will give faster ping times but at the expense of shallow water performance.

When using WinRiver, the &R30 command must be added to the User Commands after the BM7 command to override the &R20 command which is coded into WinRiver and is also the Rio Grande firmware default. This adjusts the length of the bottom track transmit pulse as a percentage of depth. The &R20 command is used with Bottom Mode 5 for slightly improved performance in shallow water. The &R30 must be added for Bottom Mode 7.

FSA-017 - Using NMEA Heading Strings

Introduction

To use the NMEA heading rather than the Navigator's internal heading, your system must meet the following requirements.

All data received shall comply with NMEA 0183 Version 3.0 dated 7/1/2000. The sentence that will be parsed is $--HDT, with checksum.

Resolution beyond 0.01 degrees will be lost.

This is available only for Navigator ADCP/DVLs with firmware version 9.15 or later.

The output baud rate of the gyro must match that of the ADCP setup (CB Command). The baud rate cannot be changed after the unit has started pinging. In other words, once pinging, the command buffer will become a NMEA buffer. Commands sent after the unit has started pinging will be ignored.

Customer shall input data at no higher rate than 10 Hz. This is more of a precautionary restriction to prevent the ping rate from being slowed too much by processing the input buffer.

Input heading data is not echoed between ensembles.

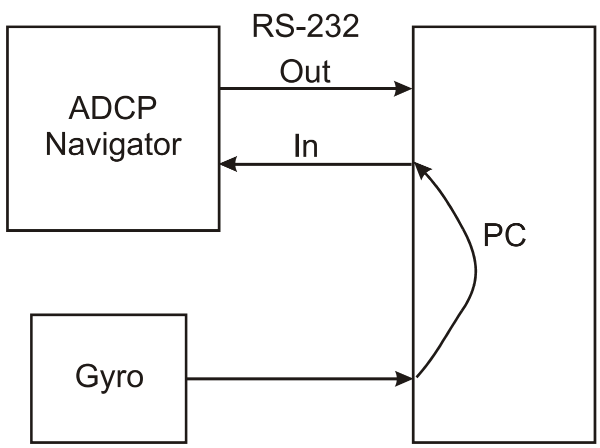


Figure 85. NMEA Heading String Setup

Setup

a. Set the EZ command to EZxx3xxxx (where x = 1 or 0) to use the NMEA heading rather than the Navigator's internal heading sensor.

b. Start the Navigator pinging.

c. Set the NMEA device to output the HDT string. The data will be parsed such that regardless of input rate, when the sensors are sampled, the last valid HDT string in the buffer will be used.

d. In instances where the heading source and the ADCP are not aligned, an EA command will need to be issued to correct the misalignment. An EB command may be needed as well; consult the WorkHorse Commands and Output Data Format guide for more information.

> **NOTE.** In order to be able to receive the HDT strings, the firmware disables the soft break feature (the +++).
>
> The CL command must be set to CL0 to disable the sleep option; otherwise the DVL will drop some headings.
>
> If the Navigator is in the Command Mode (e.g. after a break signal), it will stay in that mode until it receives a "Start Pinging" command.

HDT – Heading – True NMEA Format

Actual vessel heading in degrees True produced by any device or system producing true heading.

$__HDT,x.x,T *hh<CR><LF>

Table 75: HDT NMEA Format

Field		Description
1*	x.x	Heading, degrees True
2	T	HEX 54

Sample of NMEA HDT data: $IIHDT,247.9,T*2A

> **NOTE.** The NMEA 0183 specification states that the checksum is a simple 8-bit exclusive-or of all of the ASCII Data between the '$' and '*', exclusive.

FSA-018 - Triggering a DVL with a TTL Signal

Introduction

Interference from other acoustic devices can cause velocity and direction biases. In extreme cases it the can prevent the DVL from operating. However, it is possible to avoid this circumstance by triggering the DVL with a TTL signal.

Converter Requirements

TRDI recommends the use of the B&B Electronics Model 422TTL converter. The RS422TTL unit converts RS-422 signals to TTL signals. Two channels are used to convert from RS-422 to 0 to +5 VDC TTL signals and two channels are used to convert from 0 to +5 VDC TTL signals to RS-422. A male DB25P connector is provided for the TTL side and a DB25S female connector for the RS-422 side. For more information about the converter, see http://www.bb-elec.com/bb-elec/literature/422ttl.pdf.

> **NOTE.** The converter does not have to be optically isolated, because there is an optical isolating circuit in the DVL.
>
> The trigger input for the DVL needs to be a RS-422 signal, because the trigger signal goes into a RS422 driver inside the DVL.

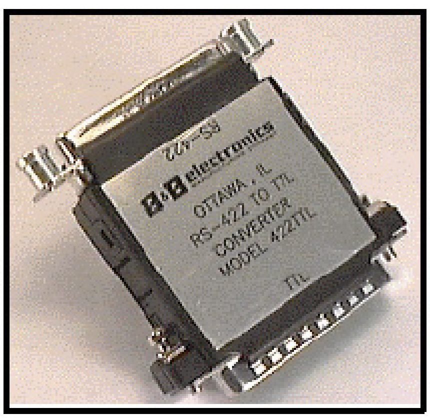


Figure 86. RS-422 to TTL Converter

Setup

The TTL to RS-422 converter must be externally powered (+12 VDC).

For triggering the DVL we only use one half of the converter.

<u>TTL side of the converter:</u>

Connect the TTL trigger signal to pin 9 and pin 7 to signal ground.

<u>RS422 side of the converter:</u>

Connect pin 2 to pin 6 RS-422 In A and pin 14 to pin 5 RS-422 In B on the DVL.

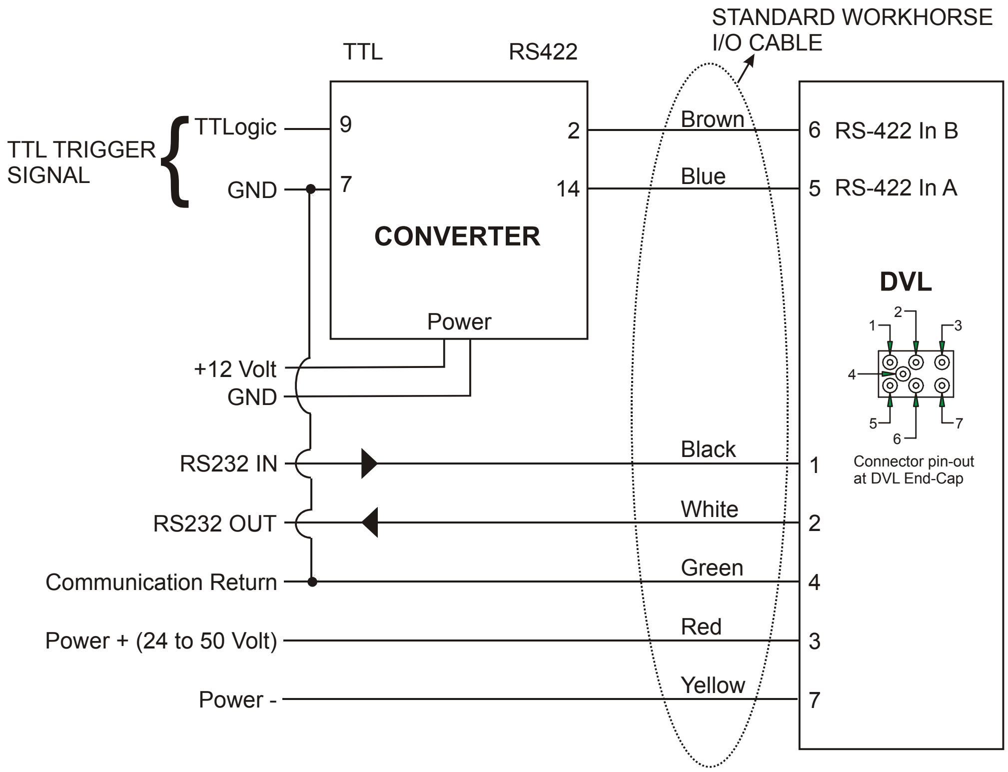


Figure 87. Triggering a DVL with a TTL Signal

Using the Low Latency Trigger Enable

The Low Latency Trigger Enable is controlled by the CX command. Set the CX command to CX1. The DVL will ping within ~300µs of the rising edge of the trigger.

NOTE. In order for the Low Latency Trigger Enable to work, the CL command should be set to CL0. Using CL1 may provide unpredictable results.

NOTE. The trigger pulse must be > 20µs and < 40ms. The optimum timing for the pulse is 20 to 30ms. If the pulse is between 40 to 100 ms, it will be ignored. A pulse over 100ms will provide unpredictable results.

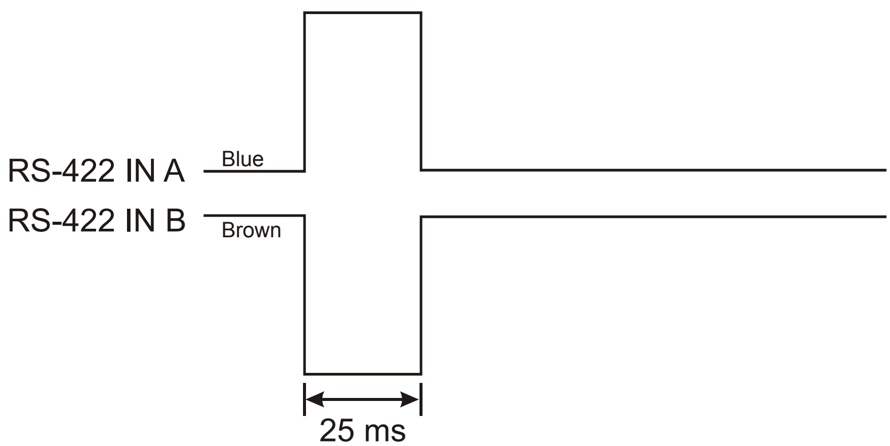


Figure 88. Timing Pulse

The DVL performs a cycle of reading sensors, transmitting, blanking, and processing (known as overhead). When the CX command is enabled, the DVL will enter a transmit trigger wait state just before the transmitting portion of the cycle. It is during this wait state that the trigger is read by the DVL. This results in the following caution:

CAUTION. The DVL does not store trigger pulses. This means that the DVL will only acknowledge pulses it sees during the transmit trigger wait state. For example, if three trigger pulses were sent to the DVL in quick succession only the pulse that occurred during the transmit trigger wait state would be used. The other pulses would be ignored and lost.

FSA-019 - ADCP Beam Clearance Area

Introduction

All ADCPs transmit signals into the water and receive the echoes backscattered from this transmission. This transmission is done in a relatively narrow beam width. Normally, the scattering is from life forms and other objects or discontinuities in the water column within this beam width (also referred to as the "main lobe"). All transducers, however, do have sidelobes. This means that a small amount of the transmitted energy falls outside of the main lobe. The transducer is designed to minimize these sidelobes and the effect in open water is that the sidelobes have no appreciable influence on the measurements that an ADCP makes.

Situations do arise, however, where very large backscattering (other than the normal scatterers), can occur in either the main beam or in the sidelobe areas. Examples are structures, cables, other instruments, etc. In these situations, the user has to take care to make sure that these scatterers do not interfere with the normal operation of the ADCP or has to be aware of the consequences if they do interfere.

This application note contains guidelines of how to best mount the transducers in adverse situations and what can be expected if an object is in either the main lobe or the sidelobe of any given transducer beam. It also recommends a "clearance zone". This is an area that we recommend keeping clear of potentially large scatterers.

> **NOTE.** The pictures and tables presented here show a single beam from a standard four beam ADCP or the phased array transducer beams. Special ADCPs may have more or fewer beams. The information and precautions presented here are intended for **all** of the beams on an ADCP.

Table 76: Beam Angles

Beam Angle	NB SC, DR, VM	BB BW, CS, DR	BB VM	WH[1]	Navigator	OS/OO
30 degrees	X		X		X	X
20 degrees		X		X		

Note[1] Sentinel, Monitor, Long Ranger, Rio Grande, and Mariner

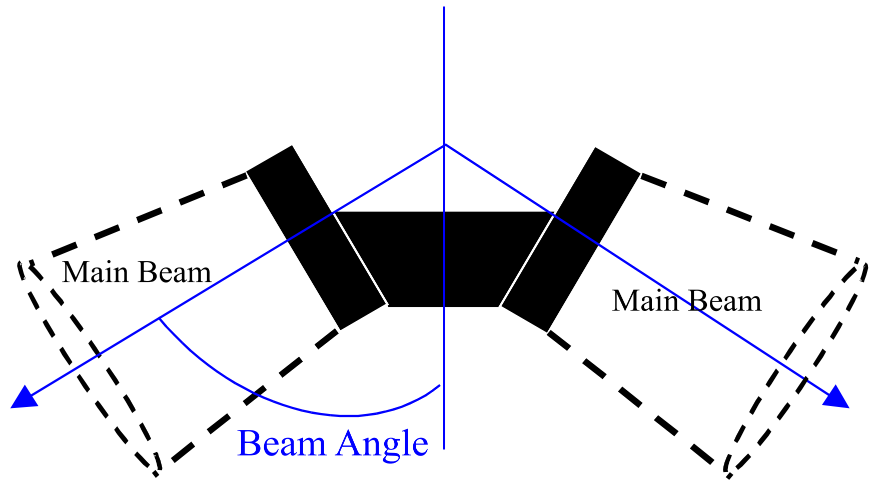


Figure 89. Beam Angle & Pattern with Four Individual Beam Transducer

NOTE. Only two beams are shown. The second pair of beams are at right angles to this pair.

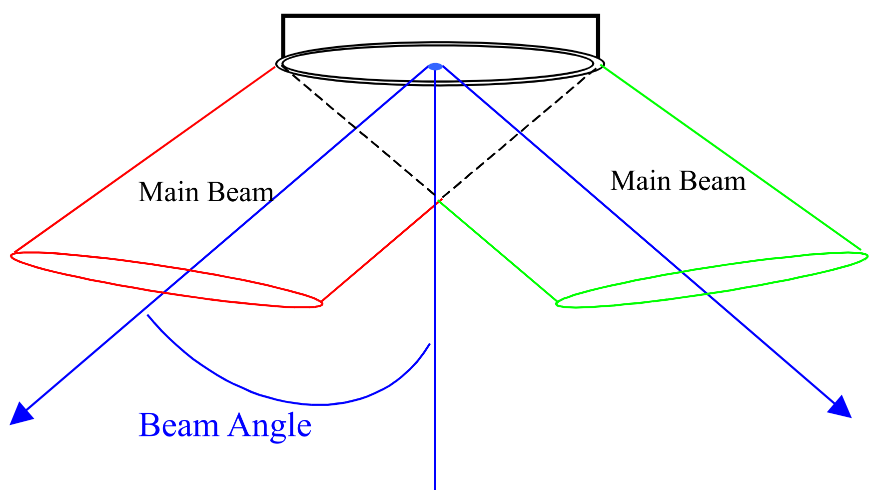


Figure 90. Beam Angle & Pattern with the OS/OO ADCP Phased Array Transducer

NOTE. Only two beams are shown. The second pair of beams are at right angles to this pair.

Table 77: Beam Widths

System Type and Frequency (kHz)	Estimated One-Way Beam Width (degrees)
NB/BB 75,150	4.0
NB/BB 300	2.0
NB/BB 600	1.5
NB/BB/WH 1200	1.5
WH Long Ranger 75	5.9
WH 300	4.0
WH 600	2.0
OS 150, 75, 38	4.0

NOTE. The values shown above are the approximate one-way beam widths to the –3dB points on the beam. In general, these values should be doubled in determining the width of the main beam.

We now will illustrate the recommended clearance zone (the area outside of the main beam to be clear of objects) on each individual beam. The drawings at this point are only showing a single beam. The single beam descriptions are the same no matter if the beam is created by an individual single beam (as in Figure 89, page 341) or if the beam is created by the phased array transducer (as in Figure 90, page 341).

Figure 91 shows the Main Beam and the spreading of the main beam width. Beam spreading is a geometric cause for echo attenuation as a function of range (for more information, see the ADCP Principles of Operation; A Practical Primer). Beam spreading is represented as a logarithmic loss in echo intensity with increasing range, where echo intensity is measured in dB. In linear units, the echo intensity decreases proportional to the range squared. ADCPs are made to minimize the beam spreading.

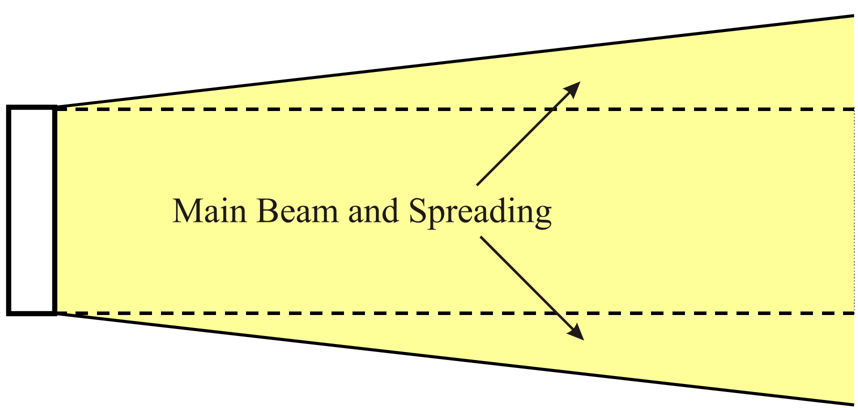


Figure 91. View of Main Beam Spreading

Figure 92, page 343 shows the Main Beam and the "Clearance Zone" (area to keep free of objects) around the Main Beam. The edge of the clearance zone is 15 degrees out from the main beam (an additional 11 degrees farther out from the main beam spreading).

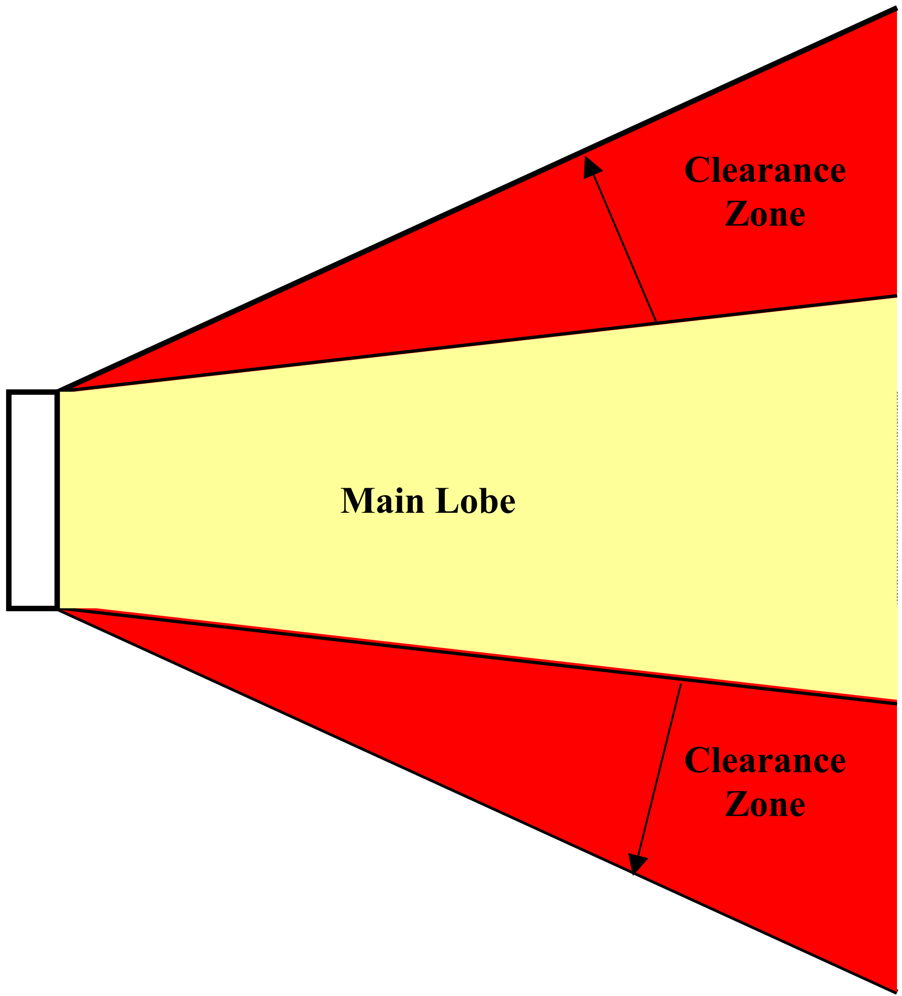


Figure 92. View of Clearance Zone Width

In Figure 91, page 342 and Figure 92 we have represented the beam width and the recommended clearance zone around each beam. In some cases, however, it may not be possible to avoid having objects in the clearance zone.

How much of a problem is an object in the clearance zone? The answer to that question depends on the size of the object and if the object appears inside or outside of the main beam width of the system. The following figures will illustrate what you must avoid and what issues might arise if you have an object inside the clearance zone.

Never allow an object to be inside of the main beam width of the system. Objects inside the main beam width are blocking the main lobe, creating beam distortion, and as a result, the entire water profile may be affected.

Any object in this area can bias the ADCP measurement for the bin the object appears in, the bin before the object, and all bins for the entire profile.

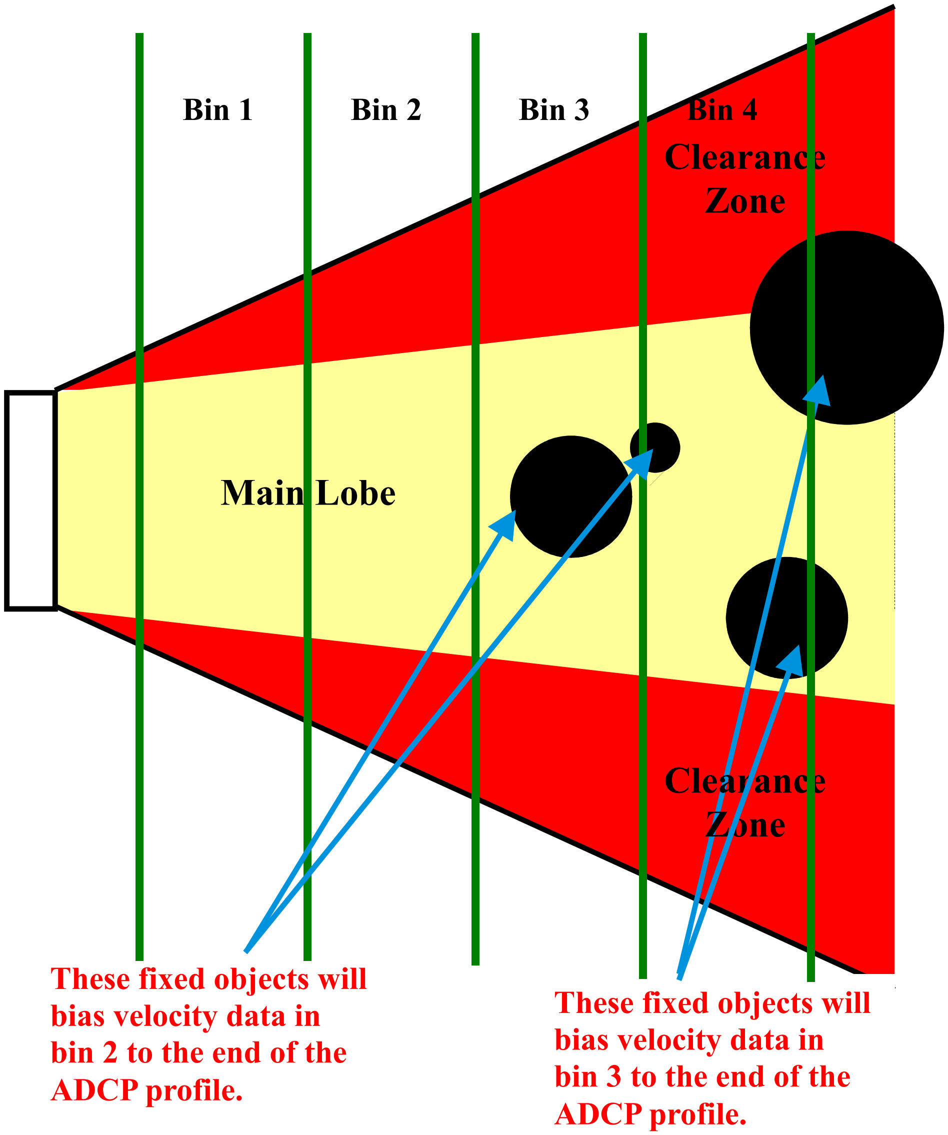


Figure 93. Profile Bias Caused by Objects in the Main Beam

An object inside the clearance zone, but not in the main beam, will bias the velocity estimate in the depth cell that the object corresponds to. Additionally, it can also bias the depth cells on each side of the depth cell shown. The amount of bias will depend on the size of the object and its reflective energy compared to that of the water. The next figures illustrate the expected bias depending on the size of the object.

In Figure 94, page 345 we show a relatively small object located inside the clearance zone of bin three. Here it is expected that bin three will be biased but bins two and four may only be biased slightly. However, it is not possible to determine that and so the recommendation is to flag bins two and four as suspect and not use them.

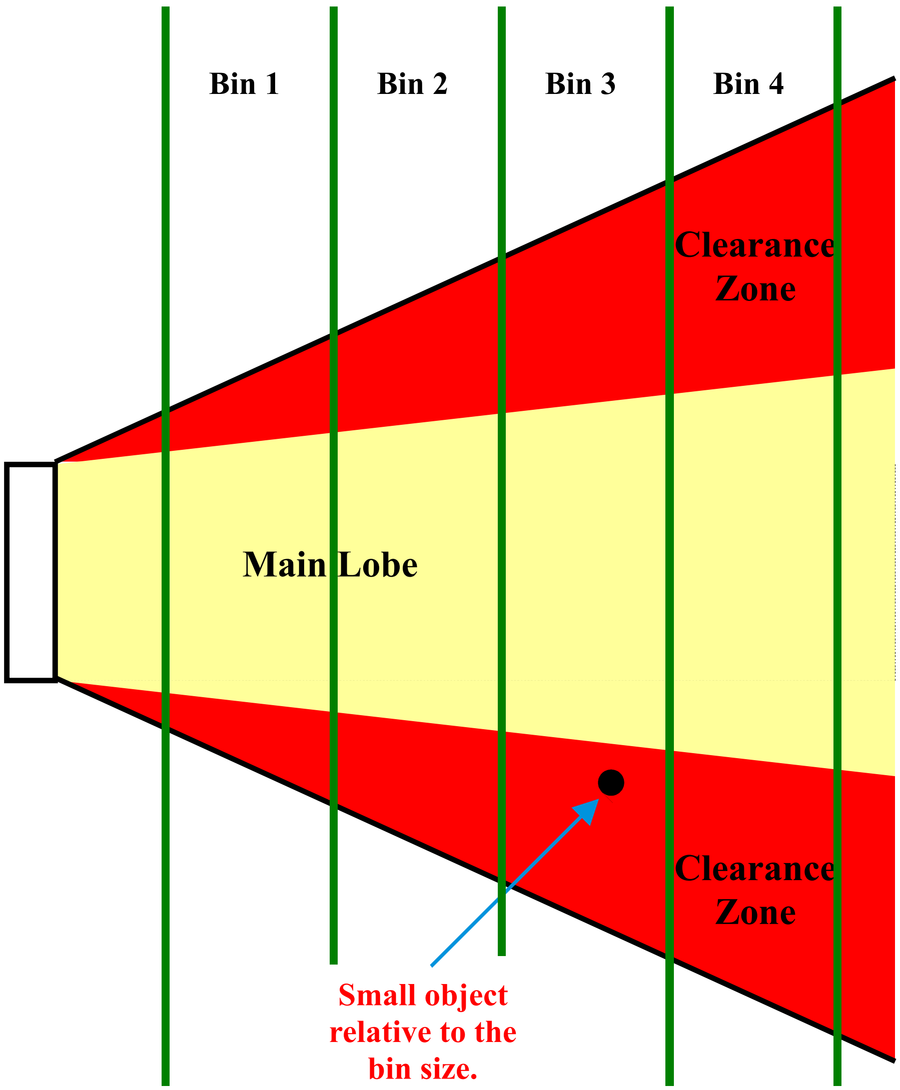


Figure 94. Small Object Biasing a Single Bin and the Adjoining Bins

In Figure 95, page 346 we show a relatively large object located inside the clearance zone of bin two and bin three. Here it is expected that bins one through four will be biased, with bins two and three being more biased than the bins one and four. Once again, it is not possible to determine how biased bins one and four are so the recommendation is to flag bins one and four as suspect and not use them.

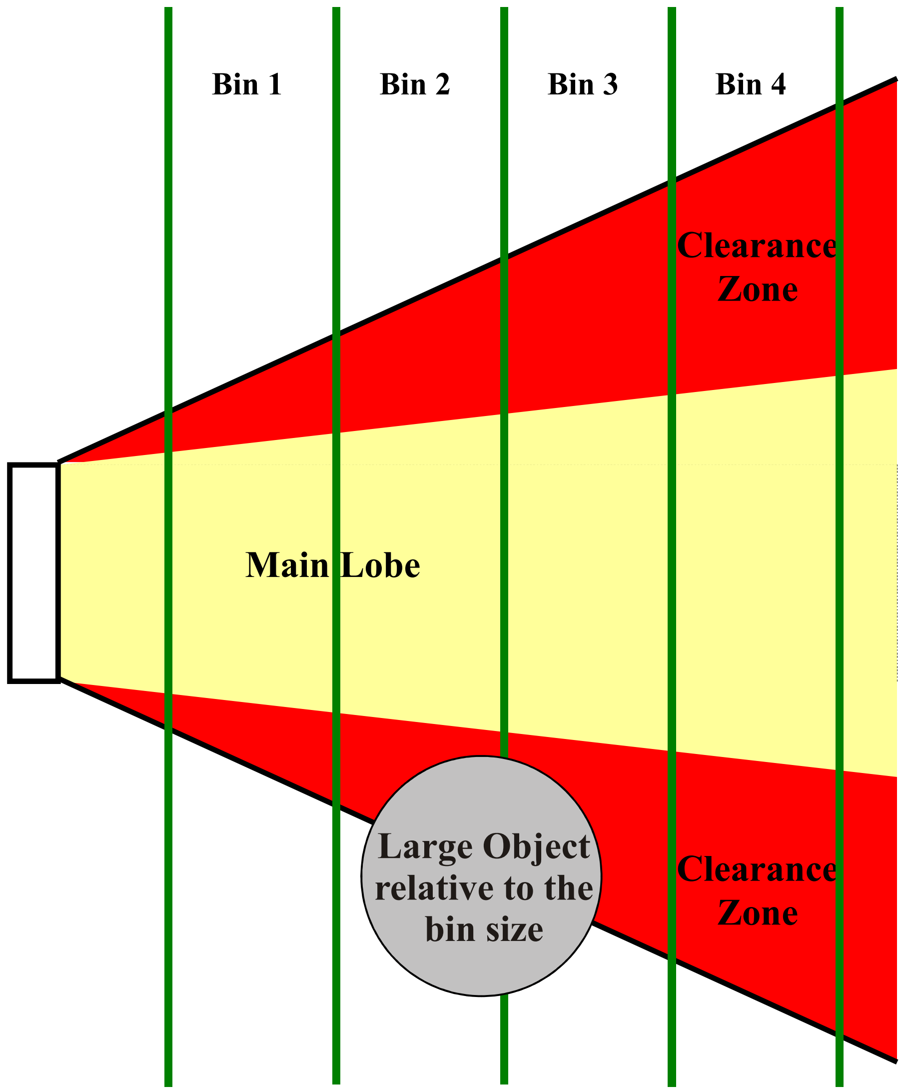


Figure 95. Large Object Biasing Two Bins and the Adjoining Bins

20 Glossary

If, after reviewing this section, you are unable to find the word/jargon in question, please **send us an e-mail** containing that word. Your questions will ensure that our glossary remains an effective reference tool for our customers.

------ A ------

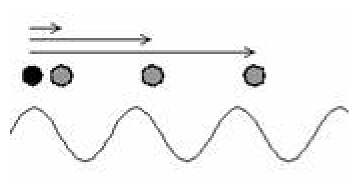
Acoustic Doppler Current Profiler (ADCP): An instrument that obtains profiles of water velocity by transmitting sound of known frequency into the water and measuring the Doppler shift of reflections from scatterers, which are assumed to be passively moving with the water.

Acoustic Window: A covering for the hull-side opening of a sea chest that is transparent to sound. A vessel mounted ADCP is typically mounted in a sea chest and the acoustic window helps to isolate it from biofouling organisms and also the flow noise generated by the vessel.

ADCP: Acoustic Doppler Current Profiler

ADCP Coordinates: Profile data is reported in an orthogonal coordinate system as referenced to the instrument. Beam 3 is forward. Sideways is to the right of forward (beam 2 for a down-looking ADCP, beam 1 for an up-looking ADCP).

Ambiguity: ADCPs determine the radial motion between a source and scatterer by measuring the phase change of the reflected signal. Because phase is periodic, this solution is multi-valued. For example, all three of the displacements shown below will return the same phase measurement, which results in ambiguity:



Ambiguity Resolution: A method to count the number of wavelengths included between two points where phase is measured, thereby removing the ambiguity associated with measuring only phase.

Ambiguity Velocity: The maximum allowable radial motion for phase measurements to be unambiguous, corresponding to a maximum observable velocity, beyond which ambiguity resolution is required.

Autonomous Underwater Vehicle (AUV): An unmanned submersible with propulsion, generally capable of navigation and accomplishing specific tasks (such as data gathering).

AUV: Autonomous Underwater Vehicle

------ B ------

Backscatter: 1) The portion of a sound wave that is reflected by scatterers directly back toward the source. 2) A qualitative measurement (in decibels) of scatterer concentration which is calculated in the WinRiver software. This calculation corrects the echo intensity data for sound absorption, beam spreading, transducer temperature, etc. and provides an excellent means of tracking relative concentration (e.g. "Is most of the sediment in the water here or is it there?"). Obtaining a quantitative measurement (e.g. "How many mg/L of bottom sediment are in this parcel of water?") requires a field calibration at the measurement site. There is a third-party software package, *Sediview*, designed for this task.

BBBatch: Utility program to allow automated conversion of a series of raw binary ADCP files to ASCII files.

BBCheck: Utility program that checks the integrity and quality of raw binary ADCP files.

BBConv: Utility program to convert some portion of a raw binary ADCP file into an ASCII file using a decoder file. Several decoder files are included on the RDI Tools CD, for example: extract only distance to first bin, extract only navigation data, etc. Complete documentation on these decoder files as well as information on how to write your own is available.

BBList: Utility program for viewing and converting raw binary ADCP data files. It is a menu-driven program offering a step-by-step process to convert raw binary files to ASCII files.

BBMerge: Utility program to convert comma-delimited ASCII files back into raw binary ADCP format.

BBSlice: A raw data sub-sectioning utility program. BBSlice converts a raw data file into a series of ASCII files, opening a new ASCII file whenever there is a jump in the sequence of ensemble numbers.

BBss: Utility program to calculate the speed of sound when given temperature, salinity and depth.

BBSub: A raw data sub-sectioning utility program. BBSub allows you to extract subsets of raw data from a large raw data file by choosing the starting and ending ensemble number.

BBTalk: Terminal emulator program for direct communication with the CPU of an ADCP or DVL.

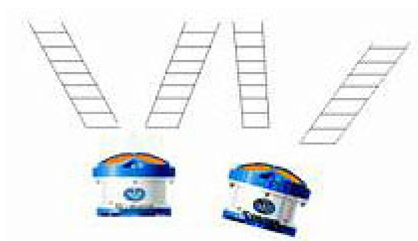
Beam Angle: The angle between a transducer beam's main axis and the vertical axis of the ADCP or DVL (typically 20 or 30º).

Beam Coordinates: Profile data is reported as referenced along each beam (i.e. no coordinate transformation is performed upon the raw data).

Beam Spreading: The extent to which the main lobe of energy generated by a transducer fans out, or spreads as an acoustic wave front, with distance from the transducer. This is proportional to λ/d where λ is the wavelength of sound generated and d is the diameter of the transducer. Note: this is why ADCP transducer diameter increases with decreasing operating frequency (and increasing wavelength).

Bin (Depth Cell): A measurement within a profile, generally equivalent to a single-point current meter on a mooring.

Bin Mapping (Depth Cell Mapping): When the ADCP is tilted; the measurements taken at equal distances along each beam are no longer in the same horizontal layer of water. For example, in the image below the tilted ADCP bins do not line up horizontally, they are offset by one bin. In this case the tilted ADCP will offset the bins on the "right" beam by one bin in order to line them up horizontally with the bins on the "left" beam before combining the measurements to compute the velocity.



Blank Zone: The area near the head of an ADCP in which no measurements are taken. This is usually the minimum distance required to avoid collecting data that is potentially contaminated by ringing, but is sometimes extended for other reasons (e.g. to begin measurement well beyond the flow influence of a mounting structure).

Bottom Discharge: When using an ADCP to measure river discharge, it is not possible to measure all the way to the bottom (due to sidelobe contamination and the finite resolution of the depth cells). In order to get an accurate approximation of the total discharge, the flow in this area must be estimated and included, usually by extrapolating the measured velocities to the bottom using a power curve fit.

Bottom Track: In moving platform applications where the bottom is within range of the ADCP or DVL, a special ping can be transmitted to measure the Doppler shift of the signal return from the bottom. If the bottom is not moving, this measurement is a very accurate measurement of the platform velocity. For ADCPs this velocity is typically used to extract the true water velocity profile from the measured velocity profile (by removing the vehicle motion from the measurements). For DVLs, this IS the desired velocity.

Bottom Track Modes: There are currently four bottom tracking modes of operation available from TRDI:

> **Bottom Mode 4:** Uses ambiguity resolution, and adjusts lags for reduced variance at higher elevations (or deeper depths).
>
> **Bottom Mode 5:** Specifically designed for reduced variance in shallow water/low elevations. It transmits several pings with computations to best determine depth and speed. This mode is the default mode, but it will automatically switch to Bottom Mode 4 if conditions warrant.
>
> **Bottom Mode 6:** Offers special narrow bandwidth operation to reduce the potential for interference or for stealth. No ambiguity resolution, instead bottom mode 6 requires user input of an approximate operating elevation (or depth).
>
> **Bottom Mode 7:** Similar to bottom mode 5, except that it is optimized for slow-moving platforms in very shallow, high backscatter environments.

Break: A wake up command to an ADCP or DVL that places the instrument in command mode.

Broadband ADCP: An ADCP that uses broadband processing.

Broadband Processing: Use of coded pulses to make multiple measurements of phase with a single ping, and thereby greatly increase the precision of the measurement.

------ C ------

Channel Master: Model name for an ADCP designed to use horizontal profiling for flow monitoring in inland waterways.

Command Mode: The state into which an ADCP or DVL goes upon receiving a break. In this mode the ADCP or DVL is waiting to receive a command. It draws relatively high power, so the ADCP or DVL will go to sleep if no command is received for five minutes.

Correlation: A key quality control parameter, this is essentially a measurement of how much the particle distribution has changed between phase measurements. The less the distribution has changed, the higher the correlation, and the more precise the velocity measurement.

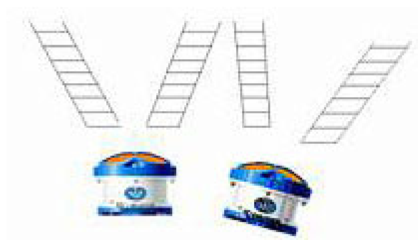
------ D ------

Dead Reckoning: A navigation method where position is estimated by measuring velocity, heading and time from the last known position.

Degaussing: Technique used to remove the magnetic field from TRDI battery packs before installation, done to minimize any effects the batteries will have on the magnetic compass.

Depth Cell (Bin): A measurement within a profile, generally equivalent to a single-point current meter on a mooring.

Depth Cell Mapping (Bin Mapping): When the ADCP is tilted; the measurements taken at equal distances along each beam are no longer in the same horizontal layer of water. For example, in the image below the tilted ADCP bins do not line up horizontally, they are offset by one bin. In this case the tilted ADCP will offset the bins on the "right" beam by one bin in order to line them up horizontally with the bins on the "left" beam before combining the measurements to compute the velocity.



DGPS: Differential Global Positioning System

Differential Global Positioning System (DGPS): Satellite-based navigation aid for precise measurement of location. When the bottom is out of range or moving, calculating the distance between DGPS position fixes and dividing by the time between those fixes can be used to measure the platform velocity.

Direct-Reading ADCP: An ADCP intended for real-time operation. Direct-Reading ADCPs do not have internal batteries or an internal recorder.

Discharge: The total flow through a section of a river. Rio Grande ADCPs obtain discharge measurements by transecting the river to measure water velocities, boat velocity, and the cross sectional area of the river and combining these measurements with estimates for the flow in the areas that can not be measured (edge estimates, bottom discharge and top discharge).

Distance Made Good: When measuring transects of data with a moving platform, this is a measure of the actual distance between the platform and the start point (i.e. variations in course track are removed).

Doppler Shift: Named for Johann Doppler (1803-1853), the German physicist who first predicted it: it is the shift in frequency caused by radial motion between a source and an observer. Specifically, $f_D = f_S (v/c)$: Where D is the Doppler-shifted frequency, f_S is the source frequency, v is the relative velocity between source and observer, and c is the speed of sound.

Doppler Velocity Log (DVL): An instrument designed to measure the velocity and elevation of a moving platform with bottom tracking. Most DVLs will switch to measuring velocity relative to the water when the bottom is out of range.

DVL: Doppler Velocity Log.

------ E ------

Earth Coordinates: Profile data is reported in an orthogonal coordinate frame as referenced to the Earth (East, North and Up). "North" can mean magnetic or true, depending on the heading input.

Echo Intensity: A key quality control parameter, echo intensity is a measure of the signal strength intensity returned to the transducer. High echo intensity can show solid targets (e.g. a boundary, obstruction or fish), while low echo intensity can show insufficient scatterers or the limits of profiling range for the environment.

Edge Estimate: When measuring river discharge with an ADCP it is not possible to measure to zero depth at the banks of the river. The flow through this unmeasured area must be approximated in order to obtain an accurate estimate of the total discharge.

Ensemble: A group of measurements (pings) considered together. An ensemble is usually the average of the individual measurements, and has a higher precision than any individual measurement.

Error Velocity: A key quality control parameter that derives from the four beam geometry of an ADCP. Each pair of opposing beams provides one measurement of the vertical velocity and one component of the horizontal velocity, so there are actually two independent measurements of vertical velocity that can be compared. If the flow field is homogeneous, the difference between these vertical velocities will average to zero. To put the error velocity on a more intuitive footing, it is scaled to be comparable to the variance in the horizontal velocity. In a nutshell, the error velocity can be treated as an indication of the standard deviation of the horizontal velocity measurements.

------ F ------

Fish Detection Threshold: Used to identify and mark as bad any velocity measurement that was potentially contaminated by a fish (because fish are generally not passively following the flow). It is a flag on the maximum allowable value for the measured echo intensity return.

Frequency: The number of wave crests passing a given point per unit time.

------ G ------

Gimbals: Frame that will support the weight of an object but allow its free rotation. Gimbals can be constructed to allow free rotation in one, two, or three axes.

Gyro: A rapidly spinning device mounted on gimbals to maintain a constant orientation. These devices are commonly used to measure heading on ships because, unlike magnetic compasses, they are unaffected by ferrous metals or by varying electromagnetic fields. They can also be used to measure pitch and roll because, unlike liquid level sensors, they are unaffected by accelerations.

------ H ------

Homogeneity: The extent to which the current measured by all four beams is the same. A key assumption of all ADCP processing is that the currents are horizontally homogeneous across the four beams. This assumption is checked for each measurement by using the error velocity measurement.

Horizontal ADCP (H-ADCP): Instrument designed to measure velocity profiles in a horizontal plane.

------ I ------

Inertial Navigation: Method for estimating the attitude and position of a moving platform (of primary interest here are AUVs) by integrating measurements from gyros and accelerometers. This integration is subject to large errors over time, so DVLs and pressure sensors are commonly incorporated as external inputs to measure and correct these errors.

------ J ------

------ K ------

------ L ------

Lag: A time delay between pulses or pings.

Long Ranger: Model name for Workhorse ADCPs of frequency 75 kHz.

Lowered ADCP (L-ADCP): Technique whereby one or two ADCPs are lowered through the water column (typically on a rosette) to obtain velocity profiles over the full ocean depth. Note that a whole body of research exists on how to properly remove the motion of the rosette from the velocity measurements obtained in this manner.

------ M ------

Main Lobe: The main focus of energy emitted from a transducer. If the transducer were a flashlight, the main lobe would be the visible beam of light.

Mariner: Model name for a Workhorse Monitor ADCP configured for underway current measurement in shallow water (as opposed to the deep water Ocean Surveyor systems).

Modes: TRDI offers several modes of operation that are optimized for certain conditions. There are currently five modes of operation for water profiling available from TRDI:

> **Mode 1:** General purpose water profiling. This is the most robust profiling mode, designed for the widest variety of measurement applications. Mode 1 can resolve high velocities and can measure over long ranges.
>
> **Mode 5:** For high resolution profiling in shallow water with low flows. Mode 5 should be used with bottom tracking. It offers the lowest standard deviation per measurement, but is also the most limited in its allowed performance envelope (e.g. low velocity flow, slow platform movement, no high shears or turbulence).
>
> **Mode 8:** Also for high resolution profiling in shallow water. Mode 8 should also be used with bottom tracking. It has higher standard deviation per measurement than mode 5, but allows a somewhat wider performance envelope.
>
> **Mode 11:** The latest in our high resolution profiling modes. Intended for the shallowest water, it is also well suited for boundary layer studies. Mode 11 should be used with bottom tracking. It allows smaller depth cells (1 cm), more depth cells, and has improved signal processing which allows faster ping rates and a wider performance envelope than modes 5 and 8. Mode 11 is intended to supersede mode 5.
>
> **Mode 12:** Offers increased resolution (1 cm depth cells) and uses multiple sub-pings to improve the standard deviation of each measurement. Mode 12 allows measurement of fast moving, shallow water; and can also be used to improve the standard deviations of any measurement (any range, any velocity) when the ADCP heading is fixed or reasonably steady.

Monitor: Model name for a direct reading Workhorse ADCP.

Moving Bottom: Some rivers carry such a heavy sediment load that they do not have a clearly identifiable bottom. In essence, the mud just keeps getting thicker and slower with depth. In such environments it is not uncommon for bottom tracking measurements to lock onto a sediment layer that is still moving, resulting in a bias to the bottom tracking velocity. This is especially important for river discharge measurements, where the vessel's navigation must be substituted for the bottom track velocity to obtain accurate results.

------ N ------

Navigator: Model name for the TRDI Doppler Velocity Log.

Narrowband ADCP: An ADCP that uses narrowband processing.

Narrowband Processing: Uses a single pulse per ping to measure velocity. The lack of coding in the pulse makes a narrowband measurement much less precise, but it allows profiling over a longer range. Narrowband processing generally requires much larger ensembles to get a precise measurement.

------ O ------

Ocean Observer: Low frequency Phased Array ADCP for cabled deployment, usually from an oilrig.

Ocean Surveyor: Low frequency Phased Array ADCP for vessel-mounted operations.

------ P ------

Percent Good: A key quality control parameter, percent good indicates what fraction of the pings passed the various error thresholds. Each depth cell reports four values for percent good, and the meaning depends on the coordinate frame. If data is collected in beam coordinates, then the four percent good values represent the percentage of the pings collected by each beam for that depth cell whose correlation exceeded a low correlation threshold. In the other coordinate frames (ADCP, Ship and Earth Coordinates), the four Percent Good values represent (in order): 1) The percentage of good three beam solutions (one beam rejected); 2) The percentage of good transformations (error velocity threshold not exceeded); 3) The percentage of measurements where more than one beam was bad; and 4) The percentage of measurements with four beam solutions.

Phase: An engineering measure of the propagation delay caused by radial motion between scatterer and source. Phase is ambiguous in that it is cyclical (e.g. 10 º is the same phase as 370 º).

Phased Array Transducer: A single, flat, multi-element transducer that uses an TRDI proprietary technique to simultaneously form all four beams. Available phased array transducers are generally low frequency (38 kHz, 75 kHz and 150 kHz) long range devices.

Ping: The entirety of the sound generated by an ADCP transducer for a single measurement cycle. A broadband ping contains a coded series of pulses and lags, while a narrowband ping contains a single pulse.

Ping Mode: Power conserving mode for a deployed ADCP or DVL, where only the power needed for the immediate deployment task is drawn (as opposed to command mode, where the ADCP consumes considerable power while simply waiting for input). This mode saves the deployment configuration so that, in the event of a power interruption, the ADCP or DVL will be able to automatically resume the configured deployment upon return of power.

PlanADCP: Windows-based software package allowing the user to configure, and evaluate the consequences of, a deployment command-set for an ADCP.

Profile: A series of regularly spaced depth cells in which the ADCP measures velocity along with several quality control parameters.

Pulse: A sound wave generated by a transducer.

Propagation Delay: The change in the travel time of sound between a source and scatterer, generally due to radial motion. As an example: if it takes longer for sound to reflect back from a scatterer than it did a short while ago (and the speed of sound has not changed), then the scatterer must be getting farther away.

------ Q ------

Quartermaster: The model name for a self-contained 150kHz Workhorse ADCP.

------ R ------

Radial Motion: Movement, which alters the distance between source and scatterer.

Range: The maximum profile length of an ADCP, it depends on several factors (note that these factors are inter-related in a complex way, and the generalizations below are intended only as rules of thumb – use PlanADCP to check specific combinations):

1. Frequency: the lower the frequency, the longer the range.
2. Depth cell size: the larger the cell, the longer the range.
3. Mode of operation: mode 1 has the longest range.
4. Bandwidth: the narrower the bandwidth, the longer the range.
5. Concentration of scatterers: generally, the more scatterers, the longer the range.

6. Temperature: generally, the colder the water, the longer the range.
7. Salinity: generally, the fresher the water, the longer the range.

Range Gating: After sending a ping into the water, the ADCP transducers listen for returned signal. The time series of the returned signal is then broken into a sequence of time segments, or range gates. Each segment is equivalent to a depth cell, with the last segment coming from the farthest range from the ADCP.

RDI Tools: Software package containing all of the BB* programs (*BBTalk*, *BBList*, etc.) as well as several commonly used decoder files.

Reference Layer: In moving platform applications where the bottom is out of range, the vessel motion can be approximated by assuming the water is motionless at some point in the measured profile. This point is the reference layer.

Remotely Operated Vehicle (ROV): unmanned submersible controlled by an operator via a tethering cable.

Ringing: After transmission the ADCP electronics, transducer and immediate surrounding equipment (particularly in vessel mounted ADCPs) all require some finite time to dampen the transmit energy, during which time any signal return from scatterers will be contaminated.

Rio Grande ADCP: The model name for an ADCP optimally configured for measurement of river discharge. A distinguishing feature of Rio Grande ADCPs is that they are designed to operate from a 12 VDC power supply (all other ADCPs operate from 20 – 50 VDC).

Rosette: Oceanographic instrumentation package found on most research vessels. Rosettes are designed to be lowered to depths of interest while collecting data of various types. Most Lowered-ADCPs are mounted on rosettes.

ROV: Remotely Operated Vehicle

------ S ------

Scatterers: Small particles or plankton in the water which reflect sound waves.

Sea Chest: Cavity in the hull of a vessel to allow stream-lined, recessed mounting of equipment such as a Vessel Mount ADCP.

Sediview: Third party software designed to use ADCP echo intensity measurements and *in situ* sampling to obtain quantitative estimates of sediment concentration.

Self-Contained ADCP: An ADCP equipped with internal batteries and an internal recorder for autonomous operation.

Sentinel: The model name for a self-contained Workhorse ADCP.

Ship Coordinates: Profile data is reported in an orthogonal coordinate frame as referenced to the ship (if beam 3 is forward then ship coordinates are the same as instrument coordinates).

Sidelobes: Peaks in sound intensity generated by a transducer found to the side of the main lobe.

Sidelobe Contamination: This only need be considered when operating an ADCP near a boundary (e.g. in shallow water). The beam angle of the main lobe of an ADCP transducer is 20 or 30º off the vertical, which means that the distance to the boundary along the ADCP centerline is shorter than the distance to the boundary along a beam. Because most boundaries will reflect very strongly (much more strongly than the scatterers), sidelobe energy can travel the shorter path directly to the surface and thereby include the "velocity" of the boundary with the velocity measurements taken along the beams at any longer distance. This potential for interference depends strictly on the beam angle. An ADCP with a 20º beam angle has the potential for sidelobe contamination at (distance to the boundary)*cos(20º), or equivalently, the last 6% of the profile. Note: Sidelobe contamination is not relevant for DVLs, which specifically look for the bottom.

Software Break: When using radio or acoustic telemetry, it is usually not possible to send a break signal. Under these circumstances an ADCP can be configured to recognize a series of keystrokes (i.e. = = =) as a break.

Source: Originator of sound of known frequency, here typically the transducer of an ADCP.

StreamPro: Model name for ADCP designed for discharge measurement in shallow waterways.

------ T ------

Top Discharge: When using an ADCP to measure river discharge, it is not possible to measure all the way to the surface (due to the blank zone and to the need to mount the transducers at sufficient depth to remain submerged with no air entraining past the transducers). In order to get an accurate approximation of the total discharge, the flow in this area must be estimated and included, usually by extrapolating the measured velocities to the surface.

Transducer: A device to convert electrical energy into sound waves, and vice versa.

------ U ------

Unmanned Underwater Vehicle (UUV): Generic term referring to both AUVs and ROVs.

UUV: Unmanned Underwater Vehicle

------ V ------

Vessel Mount: An ADCP mounted to the hull of a vessel, typically in a sea chest, and having inputs from the vessel's navigation equipment.

VM-DAS: Windows-based data acquisition package for vessel mount ADCPs. This package includes the ability to incorporate the ship's navigation equipment.

------ W ------

Wavelength: The distance between successive wave crests in a sound wave.

WinADCP: Windows-based post-processing package for ADCP data.

WinH-ADCP: Windows-based data acquisition and playback package for Horizontal ADCPs.

WinRiver: Windows-based software package for real time ADCP data gathering. It is designed primarily for measurement of river discharge and allows integration of the platform's navigation equipment. It also converts echo intensity measurements to qualitative estimates of backscatter.

WinSC: Windows-based software package for self-contained ADCPs includes configuring, testing, data recovery and viewing options.

Workhorse ADCP: The generic model name for all of the non-phased array broadband ADCPs currently produced by TRDI.

------ X ------

Xdcr: A common abbreviation for transducer.

------ Y ------

------ Z ------

ZedHed: TRDI trade name for a transducer designed to minimize ringing.

NOTES