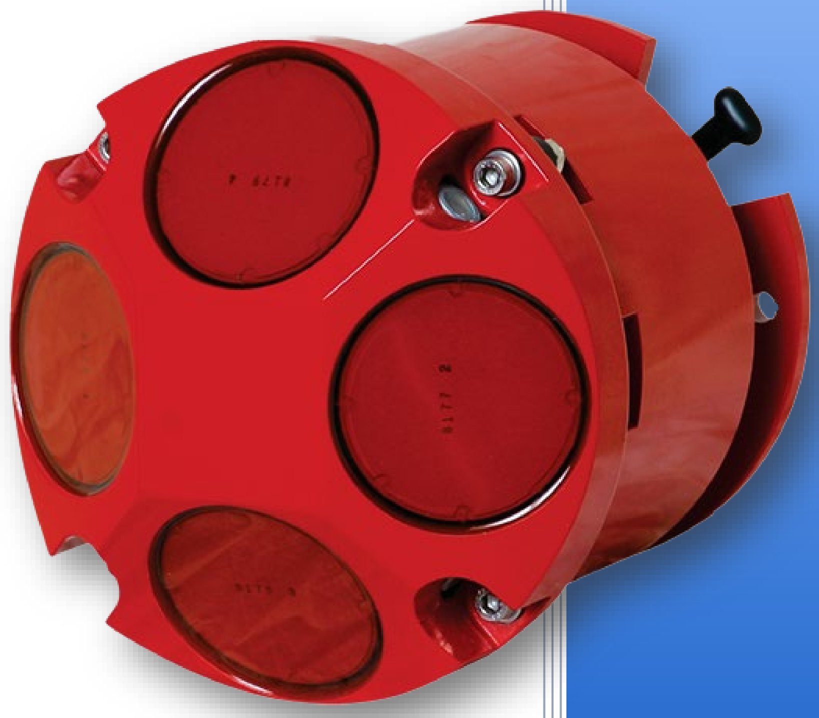
NAVIGATOR

DOPPLER VELOCITY LOG (DVL)

TECHNICAL MANUAL



P/N 957-6172-00 (June 2020)

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Revision History

June 2020

- The bore O-ring size is incorrect on page 72. The correct size is 2-258.
- Updated outline installation drawing 967-6155 to rev XC. This clarifies the differences in housing diameter between the 3k and 6k systems.
- Updated the calibration statement on page 67.

October 2018

- The defaults value for EZ in Table 20 and the command description are wrong. Should read EZ1111101 - Salinity is the only manual value.
- Added note to PA, PF, and PT4 commands to run the test in non-moving water as running these tests in air will give false failures.

December 2017

- Added an Integration Guide and Getting Started Guide to the Navigator documentation
- Replaced using *BBTalk* with *TRDI Toolz*
- Updated Outline Installation Drawings
- Added Modular Beam Outline Installation Drawings
- Updated the system overview to include the Vent Plug and Modular Beams
- Updated the section on connecting the external battery
- Updated Alignment procedure
- Added "What Beam Coordinate System should I use and why?" section to Chapter 3
- Updated the parts location drawings
- Added using the cable clips
- Updated Navigator disassembly and reassembly instructions
- Updated zinc anode replacement procedure
- Updated Replacing the CPU Lithium Battery
- Updated Table 5: Ringing Period and Table 39. WF-command Recommended Setting from 2 meters (300 kHz), 1.4 meters (600 kHz), and 0.8 meters (1200 kHz) to 3.5 meters (300 kHz), 2 meters (600 kHz), and 1 meter (1200 kHz).

October 2013

- Updated Commands and Output Data Format sections to version 9.23 firmware.
- Removed Single-Tilt Compass Calibration Procedure. This is not used on Navigator systems.
- Removed PD22 and PD24 – these output data formats are not used on for Navigator systems.
- Removed the BJ, CW, EU, and SB commands – these commands are not used on for Navigator systems.
- Added back WM, WV, WX, and WZ commands.
- Updated the PT5 test result. The Pass/Fail line was removed.

February 2013

- Added corrections for ICN070 Navigator CT Command, ICN098 Navigator PD3 Byte 2 Data Structure, ICN101 Notice of Compliance, ICN110 Navigator Pressure Sensor Location, ICN144 WF Command Setting, and ICN145 I/O Connector Lubricant
- Updated Commands and Output Data Format sections to version 9.21 firmware.
- Updated styles and fonts.
- Updated maintenance procedures.
- Updated outline installation drawings 967-1024 to 967-1027.

November 2006

- Updated commands to 9.20 firmware

How to Contact Teledyne RD Instruments

If you have technical issues or questions involving a specific application or deployment with your instrument, contact our Field Service group:

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Client Services Administration – rdicsadmin@teledyne.com

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For all your customer service needs including our emergency 24/7 technical support, call +1 (858) 842-2700

Self-Service Customer Portal

Use our online customer portal at http://www.teledynemarine.com/rdi and click on the **Support** link to download manuals or other Teledyne RDI documentation.

Teledyne Technologies Secure Extranet

Teledyne RD Instruments Firmware, software, and Field Service Bulletins can be accessed only via our Customer Support Portal.

To register, please go Here to set up your customer support account. After your account is approved, you will receive an e-mail with a link to set up your log in credentials to access the portal (this can take up to 24 hours).

Once you have secured an account, Click Here to access this data with your unique user name and password.

If you have an urgent need, please call our Technical Support hotline at +1-858-842-2700.

Conventions Used in this Manual

Conventions used in this documentation have been established to help you learn how to use the system quickly and easily.

Software 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 (*StreamPro*) and file names (*default.txt*).

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

```
Navigator DVL
Teledyne RD Instruments (c) 2012
All rights reserved.
Firmware Version: 9.xx

>?
```

You will find four other visual aids that help you: Notes, Cautions, References, and Recommended Settings.

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

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

This paragraph format tells the reader where they may find additional information.

Recommended Setting. This paragraph format indicates additional information that may help you set command parameters.

Notes

Chapter 1

AT A GLANCE

In this chapter, you will learn:

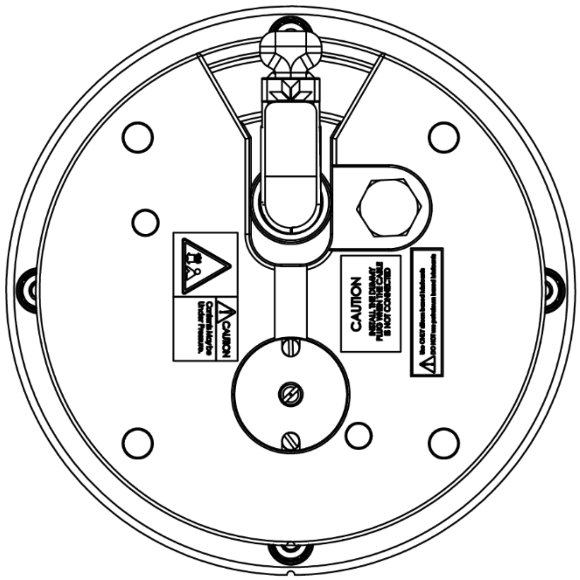
- System Overview
- Navigator Options
- Navigator Care

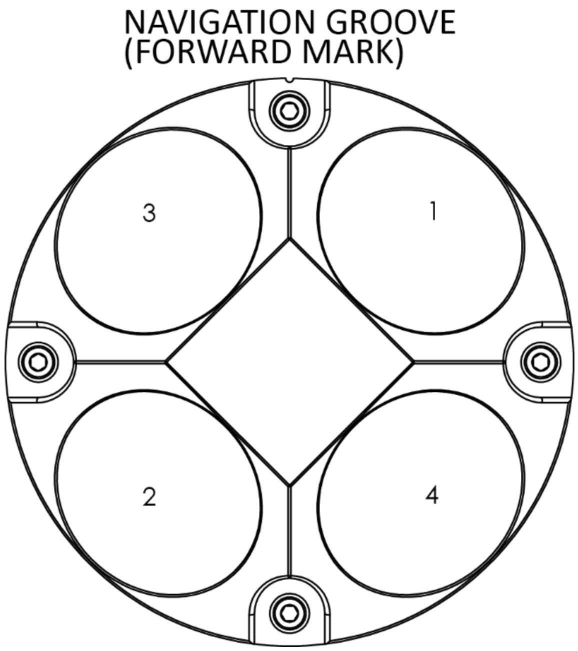
Introduction

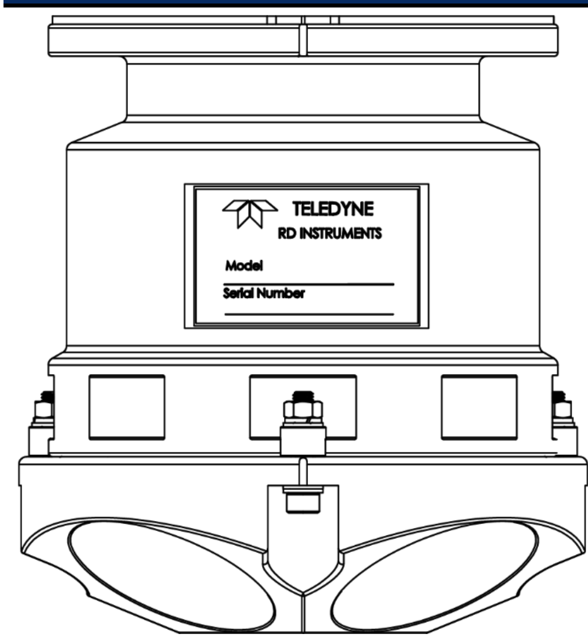
Thank you for purchasing a Teledyne RD Instruments (TRDI) Navigator Doppler Velocity Log (DVL). This manual describes the Navigator hardware and firmware.

System Overview

The Navigator DVL system consists of a DVL, cables, and software. The DVL 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.

Picture	Description
 NAVIGATION GROOVE (FORWARD MARK)	The housing mounting flange holds the I/O cable connector. When assembling the unit, match the Navigation Groove (Forward Mark) on the housing with Navigation Groove (Forward Mark) on the transducer.
	Use the Vent Plug to vent the system before opening the housing. Loosen the port ½ turn and listen for airflow; if none, then open another ½ turn and listen again for airflow. Repeat until the Vent Plug is fully removed. This will ensure no internal pressure is present when removing the housing.
	Input/Output (I/O) cable connects the Navigator DVL to the computer and external power supply. In collaboration with Teledyne Impulse and Teledyne Scientific, we've conducted extensive testing to improve the reliability of our connectors, resulting in a new compound called EPDM, which has proven highly reliable even under the most extreme conditions. These connectors are available on all new DVLs, and are also available via a connector upgrade kit for older DVLs.
	The Navigation Groove (Forward Mark) shows the mounting location of Forward.
	The pressure sensor (standard 200 Bar) measures water pressure (depth).

Picture	Description
	The orange urethane faces covers the transducer ceramics. Never set the transducer on a hard surface. The urethane faces may be damaged. The transducers in the new Navigator have been upgraded to modular cup beams as opposed to traditional potted beams. This new transducer design has proven more reliable under pressure, increased bonding strength and greatly reducing the risk of leakage. This new configuration also reduces the complexity of repairing a beam, allowing our service team to simply swap out a transducer puck, as opposed to repairing the entire transducer head. The new modular transducer assembly is compatible with older housings, allowing our existing customers to upgrade to this new feature.
	The Thermistor (embedded in the transducer head) measures the water temperature.

Picture	Description
	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.
	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 Navigation Groove (Forward Mark) with the Navigation Groove (Forward Mark) on the housing.
	Navigator DVLs can use optional memory cards (see PC Card Recorder). The maximum memory for each slot is 2GB, with the total memory capacity not to exceed 4GB.

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).
- **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).
- **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).
- **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 for dimensions and weights.
- **High-Pressure Housing** – The standard Navigator housing allows deployment depths to 3000 meters (2000 meters for systems purchased prior to December 2004). High-pressure systems are available in depth rating of 6000 meters. See the Outline Installation Drawings for dimensions and weights.
- **Memory** – Navigator DVLs can use optional memory cards (see PC Card Recorder). The maximum memory for each slot is 2GB, with the total memory capacity not to exceed 4GB.
- **Spare boards kit** – Contains a set of spare printed circuit boards for a Navigator DVL. The set does not include the receiver board (not field replaceable).

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.*

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 Installation 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 of the Manufacture date (use by Warning date).** A battery pack used to start a deployment prior to the Warning Date means that it will perform as expected and provide the required power for any deployment that was created using the TRDI planning module. 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.
- Vent the system before opening by loosening 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.**

Assembly Guidelines

- Read the Maintenance section for details on Navigator re-assembly. Make sure the housing assembly O-rings stay 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.**
- Use light amounts of silicone lubricant (such as 3M™ Silicone Lubricant (Dry Type) ID No: 62-4678-4930-3) on both the male pins and female socket to help seat the cable connectors. Wipe off excessive silicone spray from the metal portions of the pins. **Regular lubrication is required:** Apply dry type silicone lubricant prior to each connection.

- 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 may be connected while slightly wet; **do not connect under water**.

Deployment Guidelines

- 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.**

Chapter 2

INSTALLATION AND DEPLOYMENTS

In this chapter, you will learn:

- How to connect/disconnect the I/O cable
- Setting up the Navigator
- Changing the Baud Rate in the DVL
- Power, Computer, And Navigation Considerations
- Cable Routing
- Mounting the DVL
- Deploying the DVL

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.

I/O Cable and Dummy Plug

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

The dummy plugs should be installed any time the cable is removed. Use the dummy plug when the ADCP is in storage or is being handled.

When disconnecting or connecting the WorkHorse I/O cable, do not apply any upward force on the connector. Applying an upward angle as the cable is disconnected or connected puts stress on the connector. This may cause several serious problems:

1) The connector or connector pins can crack.

2) The O-ring on the bottom of the connector can be damaged.

3) The molded urethane on the connector may separate from the brass insert.

If the connector is damaged in any of these ways, your WorkHorse will flood.

Disconnecting the Cable

To disconnect the cable:

1. Release the cable clip O-ring by pulling it over the connector.
2. Grasp the cable close to the housing (see Figure 1. Your thumb should rest on top of the connector or against the edge of the housing. *Do not try to fit your hand under the cable as it passes over the housing*. This is what causes the upward force!
3. Pull the cable straight out away from the housing with a gentle rocking motion. Do not apply any upward force on the connector as it is being disconnected.

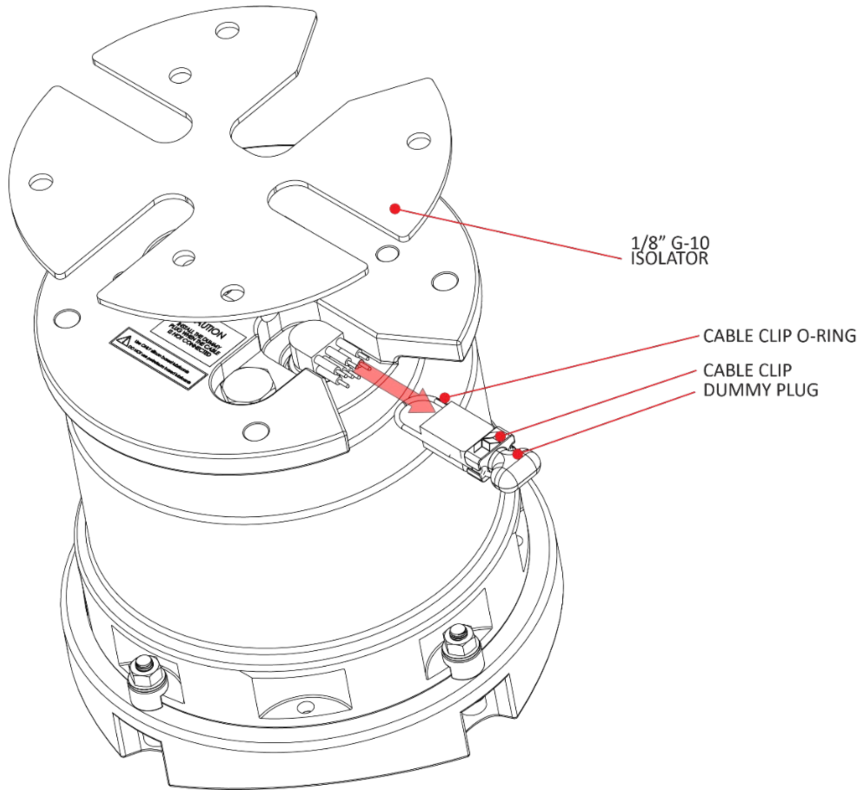


Figure 1. Removing the I/O Cable

Connecting the Cable

To connect the cable:

1. Check all pins for signs of corrosion (greenish oxidation or pitting).
2. Use light amounts of silicone lubricant (such as 3M™ Silicone Lubricant (Dry Type) ID No: 62-4678-4930-3) on both the male pins and female socket to help seat the cable connectors. Wipe off excessive silicone spray from the metal portions of the pins. **Regular lubrication is required**: Apply dry type silicone lubricant prior to each connection.

> Any lubricants to be used on or near the connectors, cables, and dummy plugs must be silicone based products only. **Do NOT use any petroleum based lubricants as this can cause damage to the EPDM rubber.**

> When the cable is connected without any lubricant, excessive force is needed to fully seat or remove the connector. This can cause several serious problems:
>
> - The neoprene rubber portion of the contact pin may tear from the metal pin.
> - Wiggling the cable side-to-side to overcome the friction as it is connected or disconnected may cause the neoprene rubber to tear or create pin-holes on the side of the connector.
>
> As a result of any damage to the neoprene rubber, corrosion may occur on current carrying pins.

3. Gently push the cable straight in toward the connector. Do not apply any upward force on the connector as it is being connected.
4. Roll the cable clip O-ring over the connector.

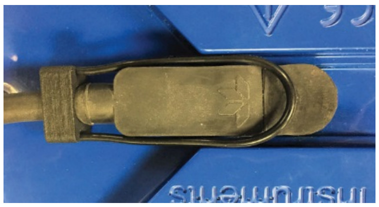
Using the Cable Clips

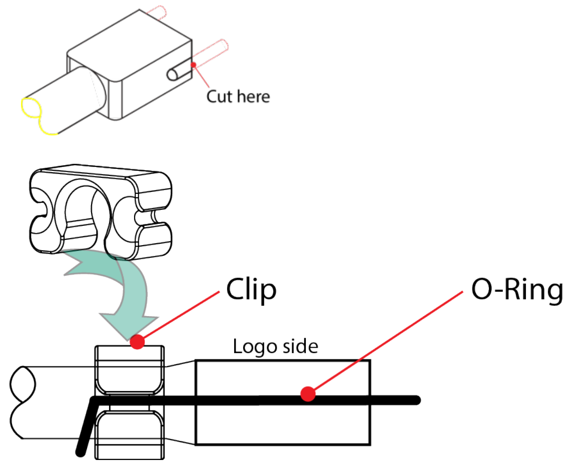
New dummy plugs and cables no longer use a molded retaining strap. To use the cable clips:

1. Remove the broken retaining strap if needed.
2. Snap the clip onto the cable or dummy plug.

- Black clip & 2-137 O-ring = cables
- White clip & 2-130 O-ring = dummy plugs

3. Route the O-ring through the clip. Connect the cable/dummy plug and then stretch O-ring over connector.





Setting up the Navigator DVL

Use this section to connect the Navigator to a computer and establish communications. Install the *RDI Tools* software in order to communicate with the DVL. 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.

To set up the Navigator DVL:

1. Connect the I/O cable to the DVL. Do so by pushing straight in against the connector. Roll the retaining strap over the connector.

> Place a light amount of dry silicone lubricant spray on the connector pins (rubber portion only). This will make it easier to connect or remove the I/O cable and dummy plug. See I/O Cable and Dummy Plug for details.

2. Attach the I/O cable to your computer's communication port. The standard communications settings are RS-232, 9600-baud, no parity, 8 data bits and 1 stop bit.
3. Connect the AC power adapter to the I/O cable.

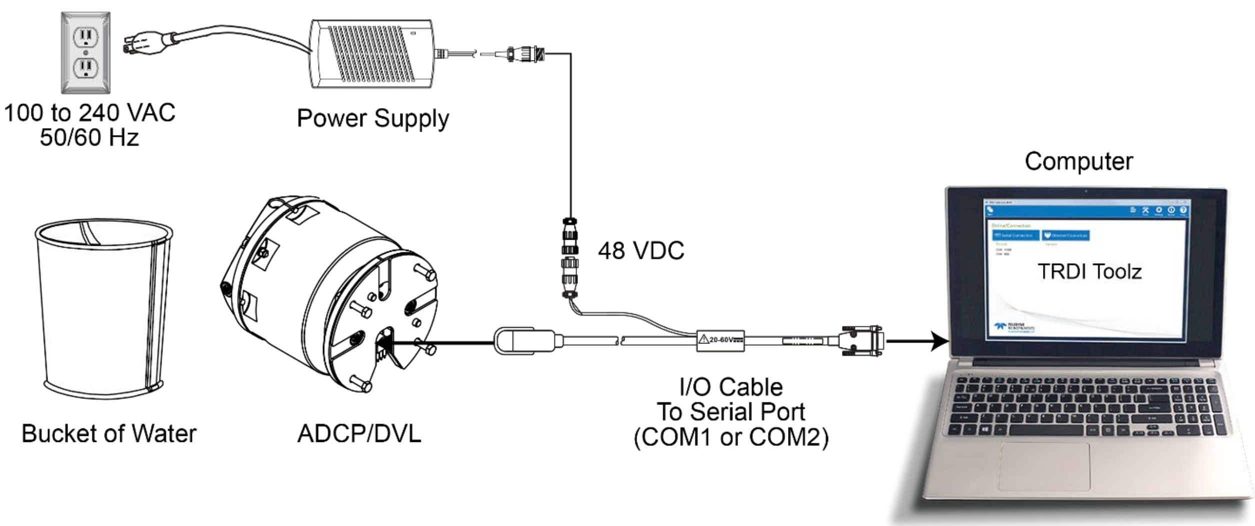


Figure 2. Navigator Connections

Serial Communication

The standard communications setting for Navigators is RS-232, 9600-baud. 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 and Changing the Baud Rate in the DVL).

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.

Connecting to the DVL

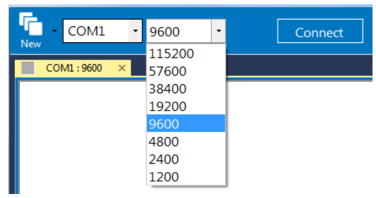
To connect to the DVL:

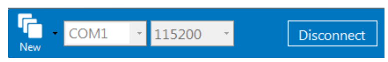
1. Select **New Serial Connection**.
2. Enter the DVL's communication settings.

   Select the **COM Port** and **Baud Rate** from the drop down lists.

   If you are unsure of the ADCP's baud rate, use **Tools**, **Find ADCP**. *TRDI Toolz* will try different baud rates until it connects to the ADCP.

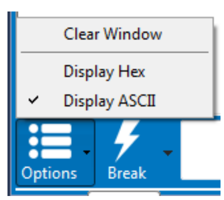
```
>{¡┐φ²∩╜╜²²jñ~ªñðgJ Checking 9600 baud
rate
Checking 115200 baud rate
==
CBREAK
Navigator DVL
Teledyne RD Instruments (c) 2012
All rights reserved.
Firmware Version: 9.xx

>
```





3. Click the **Connect** button. Once connected, the button will change to **Disconnect**.
4. Click the **Break** ( ) button. From the **Break** button drop down menu, select **Hard Break** or **Soft Break** (= = =) as needed for the DVL to wake up. The wakeup message will display in the terminal window.

5. Use the **Terminal Options** menu ( ) to display Hex or ASCII. Use the **Clear Window** option to clear the terminal window.



Changing the Baud Rate in the DVL

The DVL 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 DVL. This procedure assumes that you will be using the program *TRDI Toolz* that is supplied by Teledyne RD Instruments.

```
[BREAK Wakeup A]
Navigator DVL
Teledyne RD Instruments (c) 2012
All rights reserved.
Firmware Version: 9.xx

>cr1
[Parameters set to FACTORY defaults]
>
```

Connect the DVL to the computer and apply power.

Start the *TRDI Toolz* program and establish communications with the DVL. Wakeup the DVL by sending a break signal ( ).

At the ">" prompt in the communication window, type **CR1** then press the Enter key. This will set the DVL to the factory default settings.

BAUD RATE	CB-command
300	CB011
1200	CB111
2400	CB211
4800	CB311
9600	CB411 (Default)
19200	CB511
38400	CB611
57600	CB711
115200	CB811

Send the CB-command that selects the baud rate you wish. The table on the left shows the CB-command settings for different baud rates.

For example, to change the baud rate to 115200, at the ">" prompt in the communication window, type **cb811** then press the Enter key.

The **CB?** command will identify the communication setting.

```
>cb?
CB = 411 ----------------- Serial Port Control (Baud
[4=9600]; Par; Stop)
>cb811
>CK
[Parameters saved as USER defaults]
>cb?
CB = 811 ----------------- Serial Port Control (Baud
[8=115200]; Par; Stop)
>
```

TRDI Toolz will send the command **CK** to save the new baud rate setting.

Exit *TRDI Toolz*.

The DVL 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.

Exit *TRDI Toolz* so the communication port is available for use with other programs.

Power Considerations

The AC power adapter is designed to maintain a 400-ma supply under the ADCP's inrush current. The adapters are 75-Watt supplies, with 48 VDC, 1.5 amp outputs. They will not fall back to 0 amps, 0 volts under a load. Customer provided power supplies might shut themselves down under such a load; when that occurs, the ADCP will not wakeup. For deployments, the Navigator requires a power supply designed to supply between 20 to 50 VDC, 25 watts. Navigator power requirements are discussed below.

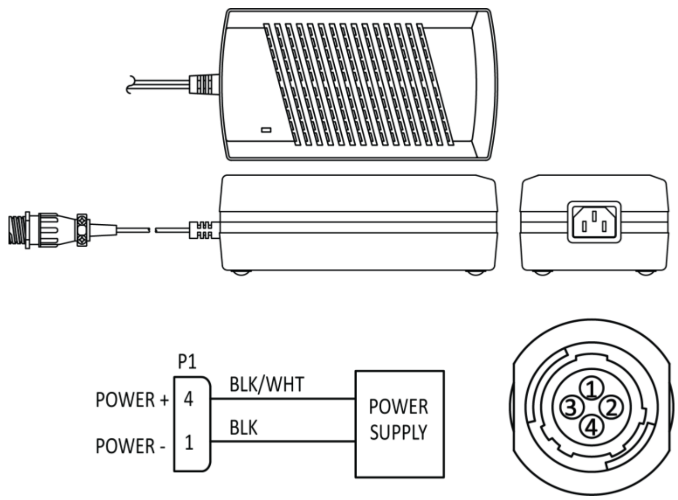


Figure 3. AC Power Adapter

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 1 shows the bottom-track range (assuming a salinity of 35 ppt and temperature of 5° C) versus supply voltage:

Table 1: 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.

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.

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.

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.

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 than 13 Volts to the Navigator's input connector if there is 0.15 amps being drawn by the Navigator. This is the minimum voltage needed to start the Navigator.
- Should the supply current limit *it must not turn its 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.

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.

Optional External Battery Pack

The optional External Battery Pack (see Figure 4) holds two 450 watt-hours batteries. 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.

Keep in mind the following about battery packs:

- TRDI specifies its battery packs to have 450 Watt-hours (Wh) of usable energy at 0°C.
- A Standard 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) falls to approximately 32 to 35 volts. However, keep in mind that this voltage is not an accurate predictor of remaining capacity.
- Transmitted power increases or decreases depending on the input voltage (within the voltage range of 20 to 50 VDC). A fresh battery provides +42 VDC. Batteries spend most of their life at a nominal voltage of +33 VDC.

The transmitted power is decreased one DB if the input voltage drops from 42 VDC to 33 VDC. For a 600 kHz DVL, each one DB drop will result in a decrease in range of one default depth cell.

- Batteries should be replaced when the voltage falls below 30 VDC (measured across the battery connector).
- 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 DVL for extended periods. The batteries may leak.
- Use batteries within one year of the manufacture date (use by warning date*).

Do not deploy the system with batteries that are older than the Warning date. It should be noted, that while a battery pack will not be dead after the Warning Date, the actual performance of the battery is in doubt, and TRDI does not warranty any deployment started with a battery pack that is past its Warning date.

TRDI batteries have four dates on them:

Manufacture Date is the date the battery was built and final tested.

TRDI Ship by Date provides the maximum duration that the battery will remain on our shelves before we will ship and is 6 months after our manufacture date.

Warning Date* provides the last date when the battery should be used to start a deployment and is 12 months from the manufacture date.

Expiration Date provides the date when the battery should no longer be considered useful and is 2 years from the manufacture date.

*A battery pack used to start a deployment prior to the Warning Date means that it will perform as expected and provide the required power for any deployment that was created using the TRDI planning module. 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.

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.

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

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

Connecting the External Battery Case

The optional External Battery Pack holds two 450 Watt-hours (Wh) batteries. To avoid affecting the compass, place the external battery case at least 30-cm away from the Navigator.

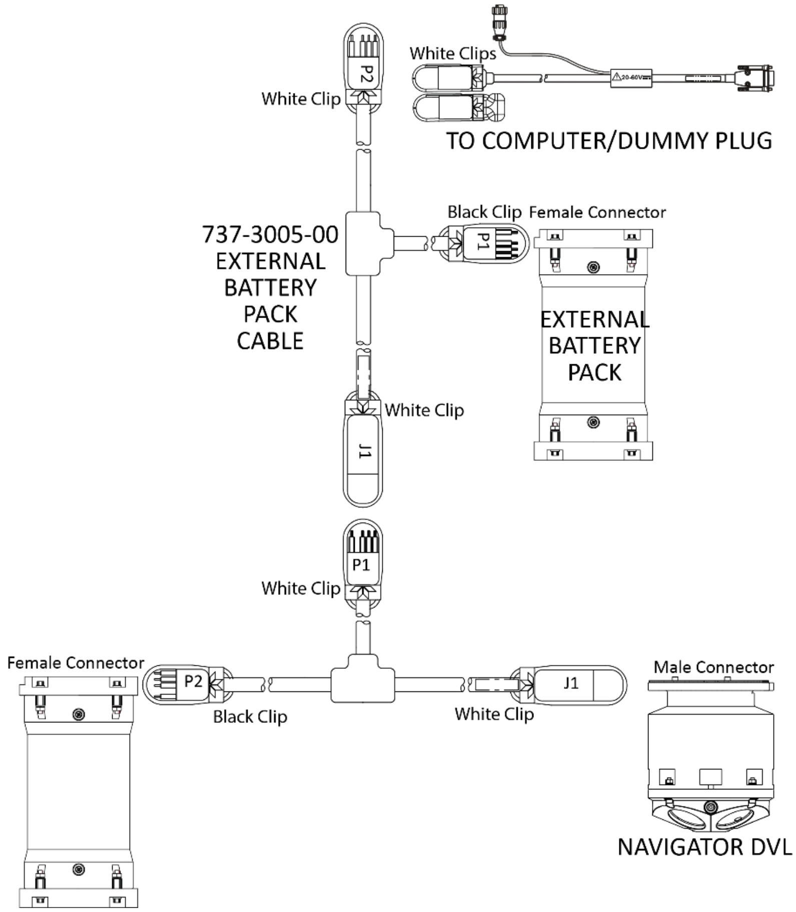


Figure 4. External Battery Pack Connection

J1 plug equipped with white clip and Long O-ring

P1 plug equipped with white clip and Long O-ring

P2 Plug equipped with black clip and long O-ring

Spare cable and dummy plug clips and O-rings are included in the spare parts kits.

The 3rd plug on the Y cable may not be used when there is only one External battery case or when the customer is not using a direct connection with the ADCP. In this case, use the Dummy plug from the ADCP to protect the 3rd plug on the Y cable.

For the P1 plug on the Y Cable 737-3005-00 use two white clip with the long O-ring, This solution works for both the cable connector or for the Dummy plug (New and old design) when you are not using the 3rd Plug on the Y cable.

The P2 Plug on the Y cable needs to be connected on the Female connector on the External Battery pack.

Use a Black Clip with the long O-ring.

Computer Considerations

TRDI designed the Navigator DVL to use a Windows® compatible computer. The computer controls the DVL and displays its data, usually through our *TRDI Toolz* program. Table 2 lists the minimum computer requirements.

Table 2: Minimum Computer Hardware Requirements

Windows XP® or Windows 7®
Pentium III 600 MHz class PC (higher recommended)
1GB of RAM (2GB or more RAM recommended)
50 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

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).

For more information about NMEA data, see FSA-017 - Using NMEA Heading Strings and the VmDas and WinRiver II User's Guides.

Cable Routing

Use care when routing the Input/Output (I/O) and external battery case 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 Navigator Cables. The cable is custom-made in lengths specified by the user. Route this cable so:

- You can install it with the connectors attached.
- It does not have kinks or sharp bends. Do not exceed a bend radius of 75 mm (3 in.).
- You can easily replace it if it fails.
- Protect the cable with abrasion resistant sleeving if zip-ties are used to secure it to structures (see Figure 5 and Figure 6). Secure the cables to the mounting structure in such a way that the cables do not move or vibrate.
- Secure all cables to the mounting structure in such a manor so that no forces are exerted on any connector. Secure the cable as close to the connector as possible without causing any stress to the connector.

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.

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.

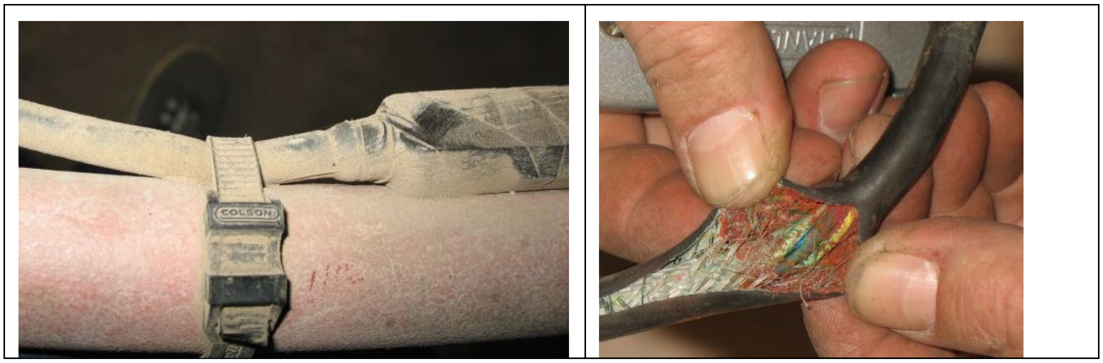


Figure 5. Do not use Zip-Ties Directly on Cables

When attaching the Navigator cables to your mount, do not zip-tie the cables directly to the structure. Zip-ties slowly cut through the cable's outer jacket and cause leaks.

Always protect the cable when attaching it to structures. Use a garden hose cut into sections and then in half at each place where a zip-tie is used to protect the cable.

Figure 6. Cables Protected with Hose

Installation Procedures (Overview)

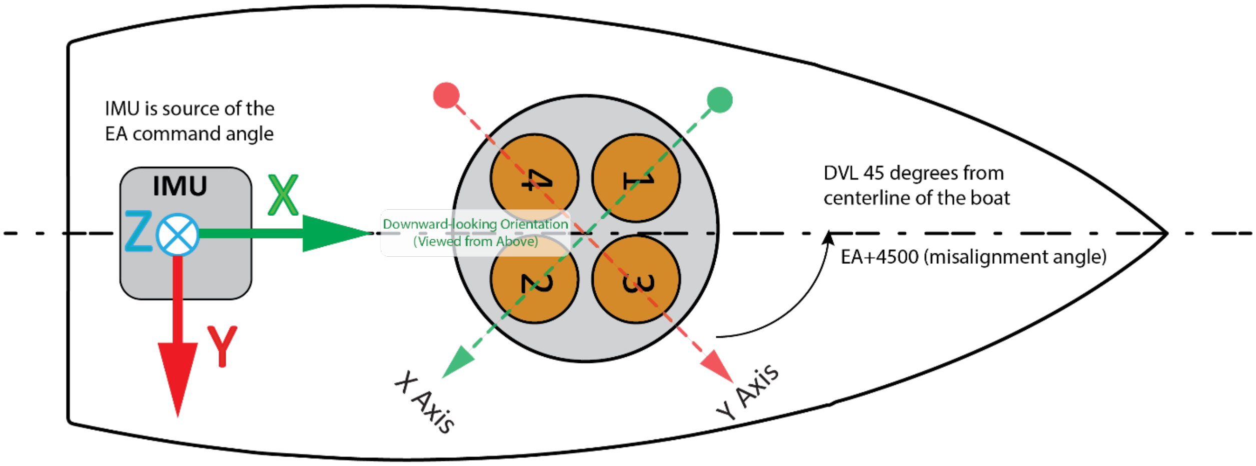
Read these steps before doing them. In general, follow them in the order listed. Some may differ for your installation, so modify them as necessary. Some can be done simultaneously (e.g., hardware installation and software loading). If you have problems or questions, call us (see How to Contact Teledyne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

1. On receipt of the system, read the Navigator Technical Manual.
2. Before installing the system, test the transducer right out of the shipping container. Do the following.
   a. All power to the system DISCONNECTED.
   b. Review Power Considerations.
   c. Connect the I/O cable from the computer to the DVL.
   d. Connect the power cable to the I/O cable connector and apply power to the system (Figure 2 shows all cable connections needed for testing).
   e. Follow testing procedures in Testing the Navigator. Test the system. If errors occur, use Troubleshooting.
3. Prepare the system for shipboard installation. Disconnect all power to the system. Disconnect all interface cables.
4. Review Installation. Install the transducer head. Mechanically align the system (see Alignment Procedures (Overview)).
5. Review Computer Considerations. Install the computer.
6. Review Cabling Considerations. As necessary, route and connect the I/O cable.
7. As necessary, load the software on the computer's hard drive. See Software for help on using the software.
8. Do the Sea Acceptance testing (see Sea Acceptance Tests). The Sea Acceptance tests include a Bottom-track (range, accuracy) check.

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 Forward 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 section for alignment considerations.

When the Navigator is aboard a vessel, the mechanical alignment of the transducer head (Forward 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, on a downward mounted DVL, if the Navigation Groove (forward mark) is pointing at the bow (Figure 7), beam 3 is rotated 45 degrees to the starboard and the misalignment angle is 45 degrees (see EA - Heading Alignment).



TRDI recommends you mount the Navigator with Beam 3 rotated to a ship-relative angle of 45° (Navigation Groove (forward mark) is facing forward). 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.

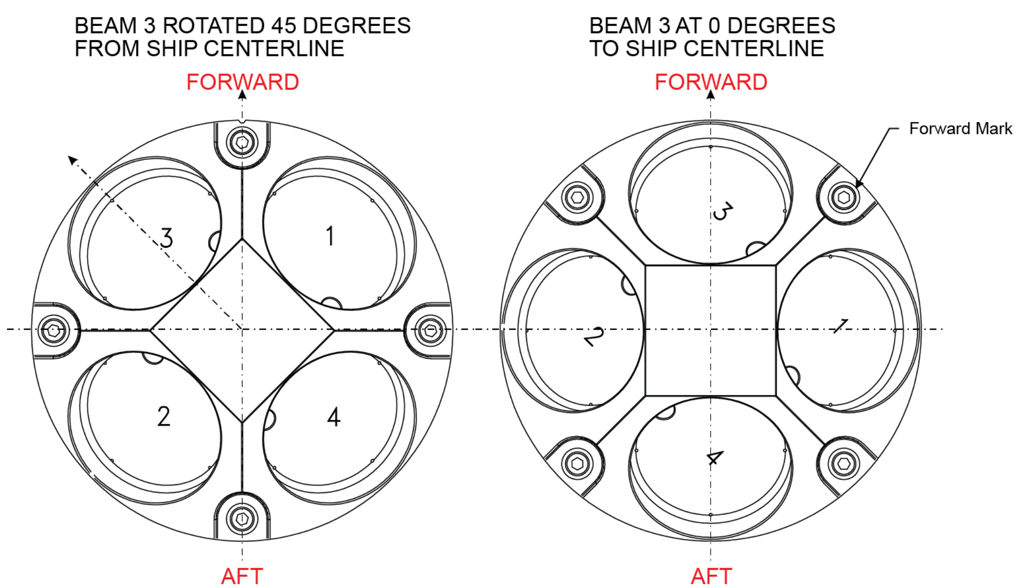


Figure 7. Transducer Misalignment Reference Points

Mounting the DVL

The preferred method of mounting the DVL is using the holes on the end-cap flange. The fallback method of mounting the DVL is to use clamps that grip the circumference of the housing. See the Outline Installation Drawings for dimensions.

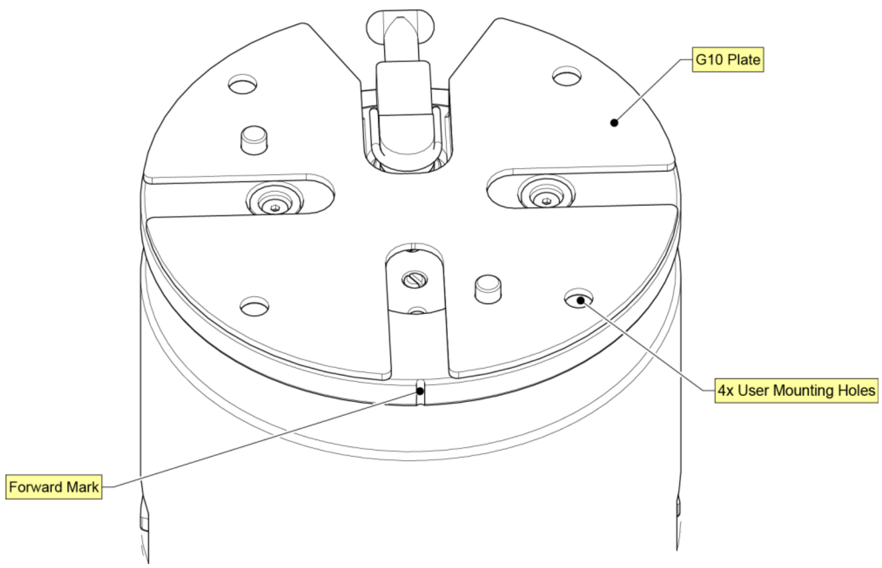
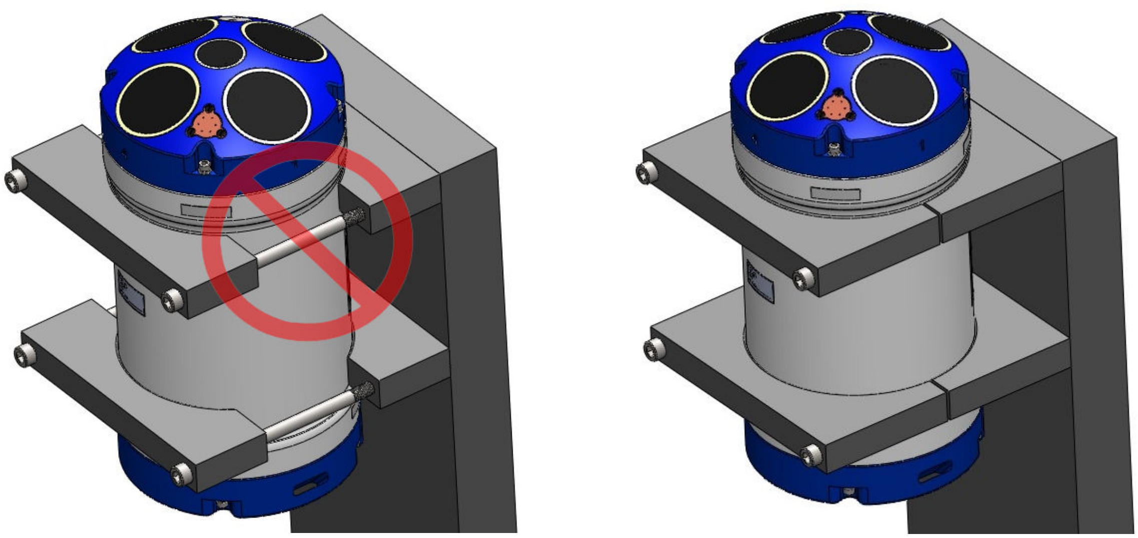


Figure 8. End-Cap User Mounting Holes

Only use stainless steel hardware.



Poor Design	Good Design
When clamping the DVL or external battery case to a mount, the clamp must not have a large gap between the front and rear clamp. Using this type of design can cause the housing to deform or even break if the clamps are over tightened. This will cause the DVL to flood.	Design clamps that fully surround the housing. Design the gap as small as possible so that when the clamp is fully tightened it will not deform the housing or cause excessive pressure on the housing.

Figure 9. Mounting Clamp Design

Over-the-Side Mounting

The over-the-side mount is common if you want the ability to move the Navigator from one platform to another. 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 style is 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.

The most common over-the-side mounting method for Navigator DVL s uses a Kentucky Mount style. For more information, see the following:

- http://hydroacoustics.usgs.gov/movingboat/pdfs/KYMount.pdf
- http://hydroacoustics.usgs.gov/movingboat/mbd_deployments.shtml

Our transducer assembly is sturdy, but TRDI did not design it to withstand collisions with all floating objects. TRDI strongly suggests you protect the DVL if this is a possibility.

Avoid using ferro-magnetic materials in the mounting fixtures or near the DVL. They affect the compass. Use titanium or 316 stainless steel hardware.

Over-the-Side Mounting Special Considerations

Use the following suggestions when mounting the DVL to a platform:

- 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.

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.

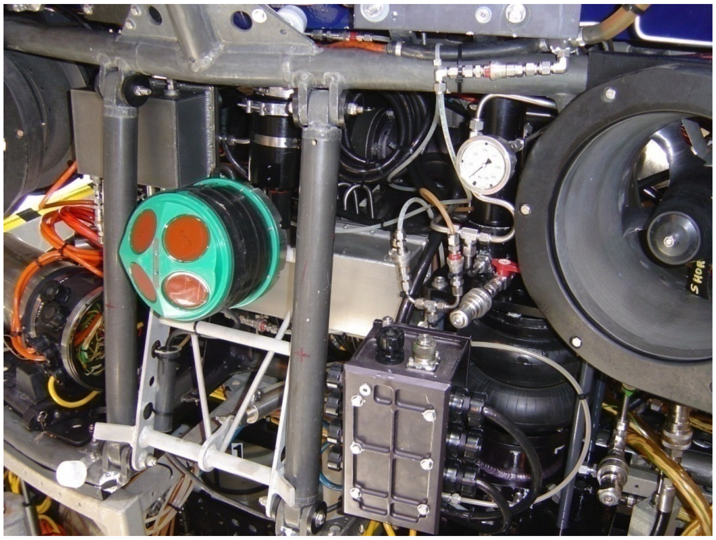


Figure 10. Example of a Navigator Mounted on a ROV

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).

Location

Ideally, you want to install the transducer:

- 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 and FSA-019 - ADCP Beam Clearance Area).
- 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).
- 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.

Sea Chest In-Hull Mounting

A sea chest (Figure 11) 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.

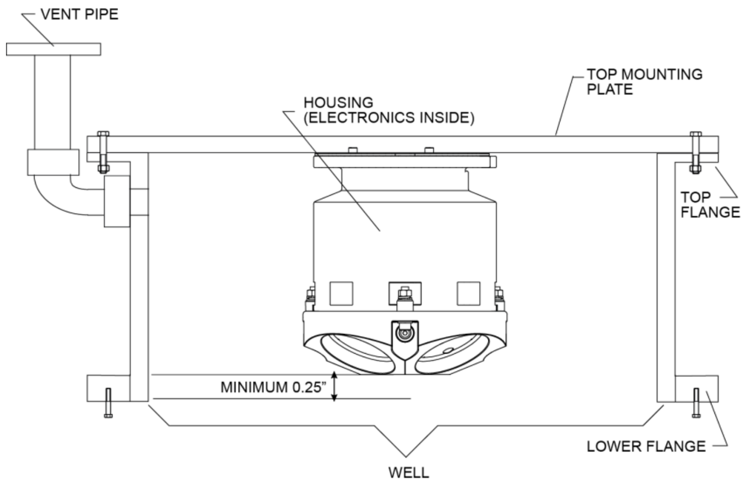


Figure 11. Sea Chest Mounted Transducer

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.

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, than 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.
- Flow noise is reduced, see Flow Noise.
- 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.
- 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.

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: Maximum 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, than 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: λm=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.

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.

Orientation

We recommend you mount the transducer head with Beam 3 rotated to a ship-relative angle of 45° (see Alignment Procedures (Overview) and Figure 7). 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), 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).

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.

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 12.

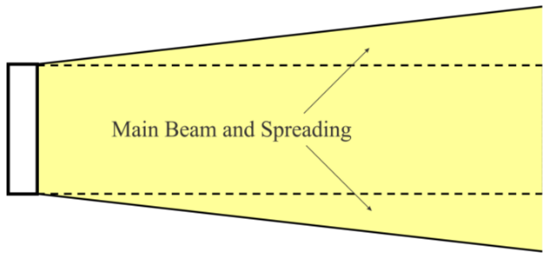


Figure 12. Main Beam and Spreading

Any acoustic obstacle in the Main Beam and Spreading will interfere with the DVL measurement. DVL transducers have sidelobes which could collect energy backscattered by acoustic obstacles in the 15° clearance cone as depicted in Figure 13:

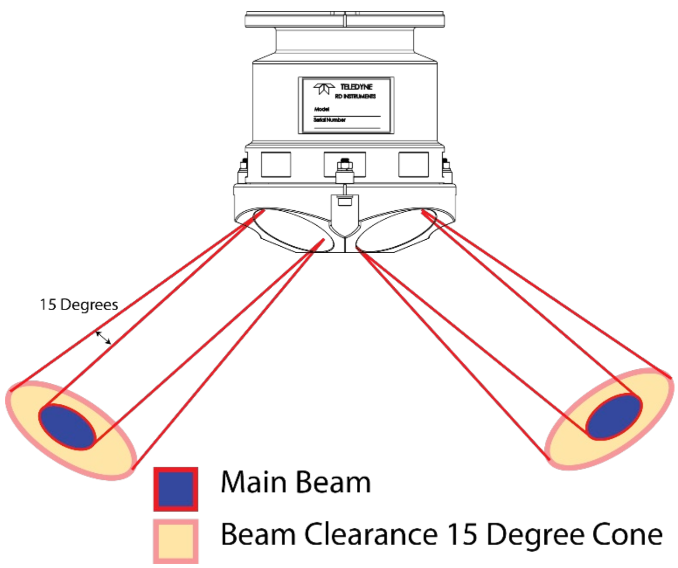


Figure 13. DVL Main Beam and Clearance 15° Cone

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 for instructions when Water tracking or Profiling).

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.

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) may help reduce the bubble problem, but can cause ringing (see Acoustic Isolation) and attenuation problems.

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.

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 Zinc Anode Inspection and Replacement). 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.

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

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, than it will receive both the return signals from the water and the "ringing." Both of these signals are than 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	3.5 meters
600 kHz	2 meters
1200 kHz	1 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) 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.

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 and BL - Water-Mass Layer Parameters 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.

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, than 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).

The DVL transmits a pulse or series of pulses that contain four carrier cycles, i.e. 4T on Figure 14.

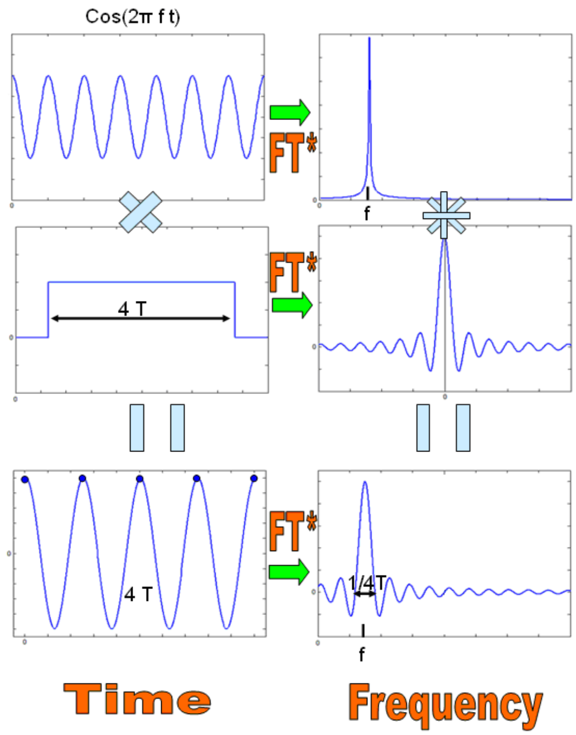


Figure 14. DVL Carrier Cycles

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

As depicted in Figure 14, an acoustic wave is sent into the water by exciting the transducers with an electric sinusoidal signal, cos(2πft) – (Figure 14 - top left corner). Its Fourier Transform is a Dirac function centered on f the frequency of the sinusoidal signal (Figure 14 - 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 (χ) = sin(χ) / χ (Figure 14 - 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 14 - 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 14 - bottom right corner). The resulting transmit frequency bandwidth is 25% of the carrier frequency, i.e. 4T = f/4 = 25%f (or .25f). 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

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). 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 15).

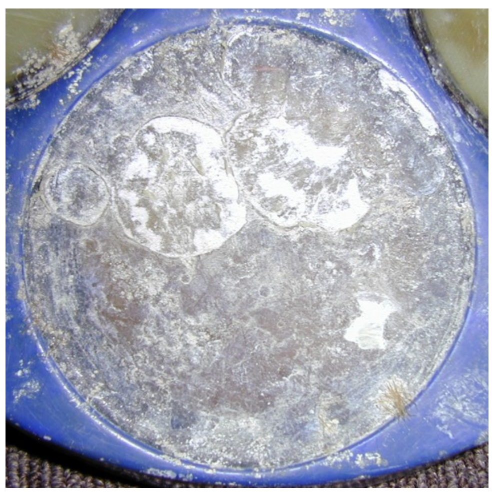


Figure 15. Barnacle Damage to Urethane Face

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 (see Applying Antifouling Paints).

Deploying the Navigator

The Navigator provides a powerful combination of sensors in a compact package for ROV, AUV, or towed fish navigation and control. A member of the Workhorse DVL™ Series, the Workhorse Navigator measures 3-D bottom track and/or water-referenced vehicle velocity and altitude. It also measures heading, pitch and roll, and temperature. The Workhorse Navigator can be upgraded to perform water current profiling and dredge plume or sediment tracking.

When considering ROV/AUV applications, there are three options on how the Navigator is set up to collect data and how the data is displayed.

- RDI's *PlanADCP* software is used to develop the command file and RDI's *TRDI Toolz* software is used to send the commands to the DVL; the user provides software to handle data collection and display.
- The user provides everything.
- The user uses a third party software package such as EIVA.

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.

To create a command file:

1. Select **Navigator** as the **Type of ADCP**. Click **Next**.
2. Select the frequency of your DVL. The default settings and consequences are based upon the DVL frequency. Click **Next**.
3. 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**.
4. 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**.
5. Select **Do Not Collect Water Profiles**. Click **Next**.
6. The wizard is now finished. Click **Finish**.
7. 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 minimal setup you need to use to collect good data.

8. Review the Storage and Power consequences. Ensure you have enough resources for the deployment.
9. Move the cursor to the **Notes** section. Use the area to include notes about the command file or deployment.
10. If you make any changes to the input parameters, resave the file. On the **File** menu, click **Save** to save the command file.

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
EZ1111101
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 7 explain each command set or added by *PlanADCP*. These commands directly affect the range of the DVL, standard deviation (accuracy) of the data, and power usage. Table 7 explains the commands used in the sample command file for a 300 kHz Navigator with Bottom Track.

Table 7: Command File Created Using *PlanADCP*

Command	Choices	Description
CR1	Sets factory defaults	This is the first command sent to the DVL 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.

Command	Choices	Description
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.
EZ1111101	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.

Although these are our recommended minimum commands, they may not be the only commands you need for your deployment to be successful!

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** for detailed information on editing the command file.

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.

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.

1. In *PlanADCP*, on the **File** menu, click **Edit**.
2. Select the command file and click the **Edit** button.
3. Make changes to the command file as needed (see Table 8).
4. 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.

1. To view the **Expert** screen, click the **Advanced** button to move to the **Advanced** screen, and then click the **Expert** button.
2. Click inside the command box to add a command (see Table 8).

Table 8: Recommended Commands to Add or Edit

Command	Choices	Description
BKx	BK0, 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.
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 Navigator Technical Manual, Command section for details and FSA-012 (included with the Navigator Technical Manual).
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, PD22, PD24	Sets the output data format. See Output Data Format section for details.

The CR1 command must be the first command sent to the DVL (see Table 7). The CK command must be sent just before the CS command. Other commands may be sent in any order.

Preparing the DVL for Deployment

Use the following steps and the Deployment Checklist to set up the Navigator for a deployment.

Deployment Checklist

- ❑ Test the DVL using *TRDI Toolz*
- ❑ Seal the DVL for deployment
  - ❑ Install new O-rings; use silicone lubricant
  - ❑ Use fresh desiccant inside DVL
- ❑ Visually inspect the DVL
  - ❑ Check the transducer head condition
  - ❑ Check the zinc anode condition
  - ❑ Check the housing paint condition
  - ❑ All mounting hardware installed
  - ❑ Transducer faces clean and free from defects
- ❑ Verify compass alignment using *TRDI Toolz*; if necessary, re-calibrate
- ❑ Are biofouling precautions needed?
- ❑ Zero pressure sensor (optional) at deployment site with AZ-command

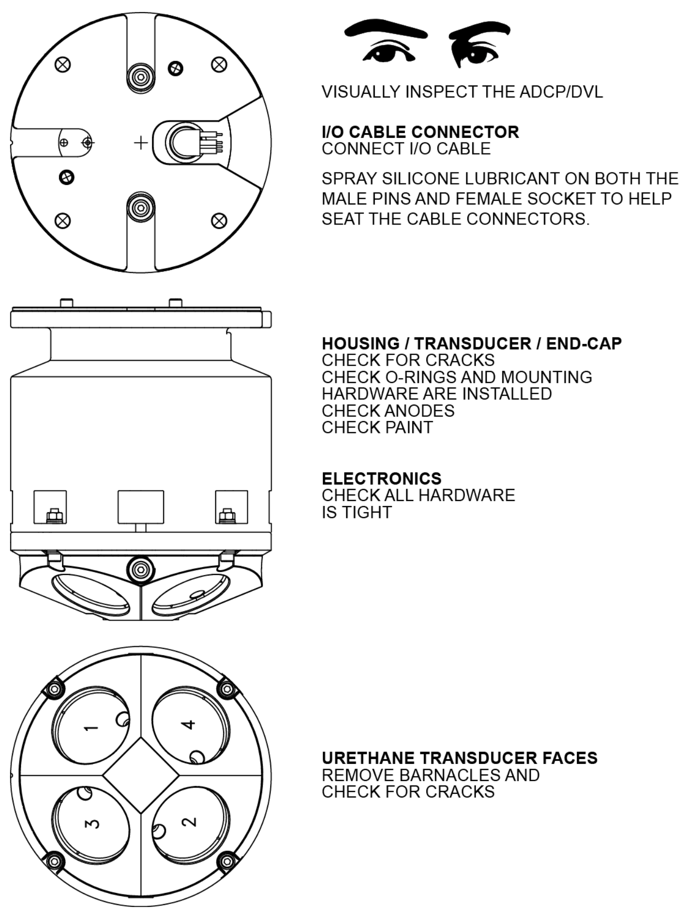


Figure 16. Visual Deployment Checklist

Things to remember while preparing the DVL

- Use the Deployment Checklist to verify that the DVL is ready for the deployment.
- Test the DVL using *TRDI Toolz*. Some tests will fail if the DVL is not placed in standing water while the tests are being run.
- *Desiccant* lasts a year at specified Navigator deployment depths and temperatures. Remember that desiccant rapidly absorbs moisture from normal room air. Replace the desiccant and O-rings whenever the Navigator housing is removed.
- Verify the compass calibration before deployments.

Use *TRDI Toolz* to Send the Commands to the DVL

To send the commands to the DVL:

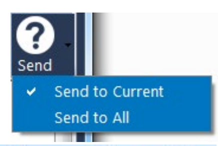
1. Start *TRDI Toolz*.
2. Send a BREAK to the Navigator by pressing the **Break** ( ) buton. When the Navigator receives a BREAK signal, it responds with a wake-up message similar to the one shown below. The Navigator is now ready to accept commands at the “>” prompt.

```
[Break Wakeup A]
Navigator DVL Version 9.xx
RD Instruments (c) 1996-2013
All rights reserved.
>
```

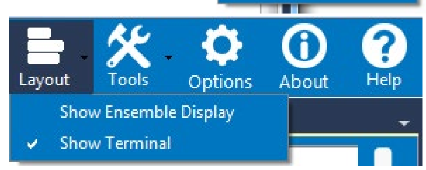
3. On the **Tools** menu, select **Script Editor**.
4. Click the **Open** icon and select the file to run from the scroll-down list. If no extension is given for the script file, an extension of *.txt is assumed.

Script files can have any extension as long as they are ASCII text files.
Use TRDI’s software *PlanADCP* or *Plan* to create a command file.

5. Click the **Send** icon. Clicking the drop-down menu will show the options to **Send to current** or **Send to all**. Use the **Send to all** feature to send the same script file to all connected ADCPs.



6. Use the **Layout** menu to show or hide the Ensemble Display and Terminal windows. The Ensemble Display shows limited situational data (Ensemble Time, Temperature, Heading, Pitch, Roll, Bottom track range/velocity, Vertical Beam range) in tabular form from the ADCP data stream, when present.



Note that the Ensemble Display is off when *TRDI Toolz* is first started.

Script files can have *.rds, *.txt, *.scr, or any other extension as long as they are ASCII text files. Double-clicking a *.rds file will automatically start *TRDI Toolz* and run the script file if the **Connect to Last Open Port** is selected on the **Options** screen (see the RDI Tools User’s Guide for details).

Whenever the Navigator pings, an internal beeper makes an audible beep. The beep consumes negligible energy and tells you the Navigator is pinging.

NOTES

Chapter 3

FREQUENTLY ASKED QUESTIONS

In this chapter, you will learn:

- Frequently Asked Mechanical Installation Questions
- Frequently Asked Electrical Installation Questions
- Frequently Asked Operational Questions

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 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). Also see Frequently Asked Electrical Installation Questions and read the section on alignment (see Alignment Procedures (Overview)).

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).

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). 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 and FSA-010 - Using Acoustic Windows).

Where is the center of rotation?

The center of rotation is indicated on the outline installation drawings.

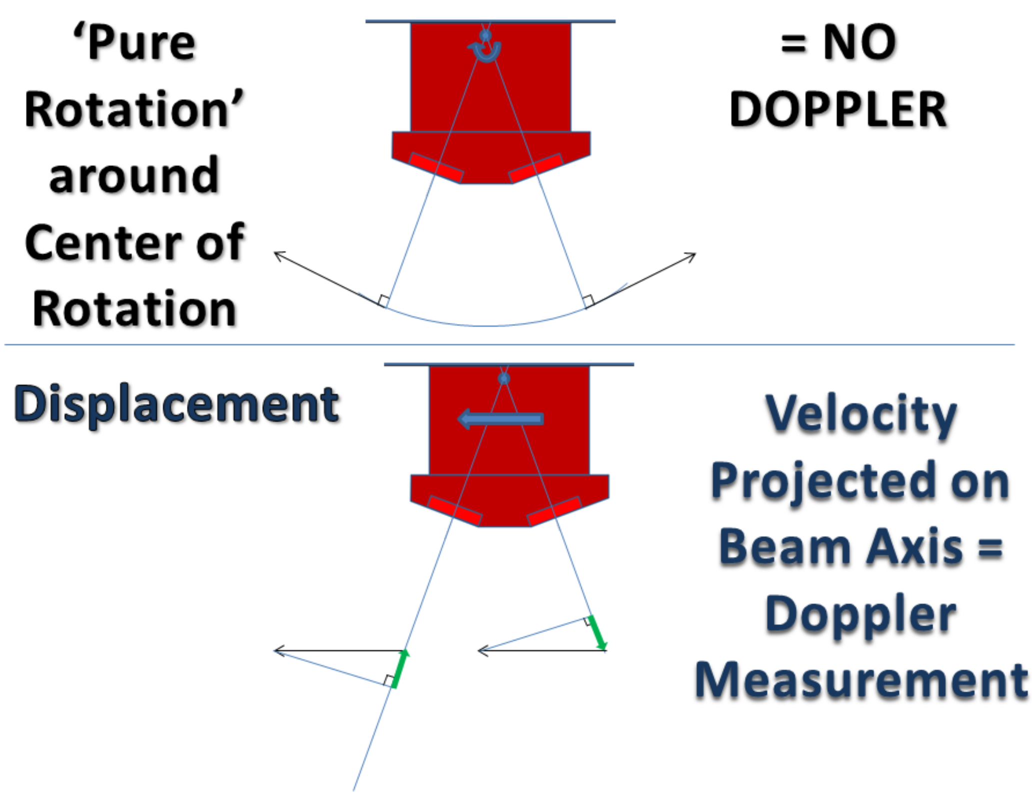


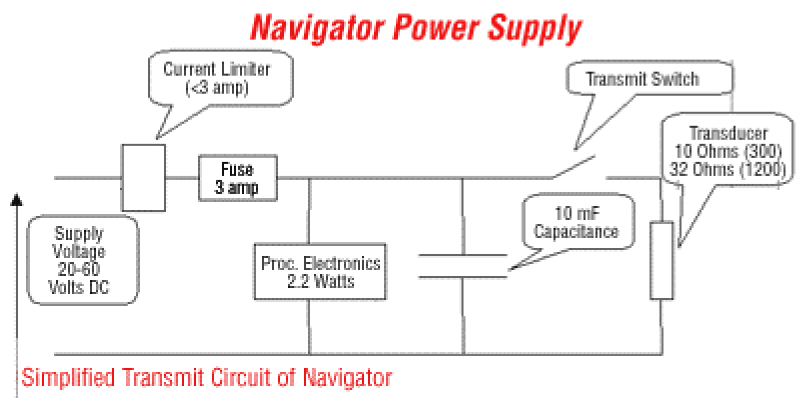
Figure 17. Center of Rotation

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

Frequently Asked Electrical Installation Questions

How much power do I need?



Navigator Power Supply Requirements

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 set up to wait for input before each ping. To set up 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). 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 RDS3:** Using RDS3, the instrument can be set up 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, than 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 than wait for a trigger before pinging. Different ping synchronization

rules are available – see SA - Synchronize Before/After Ping/Ensemble. Setting the RS-485 lines to a break state for not less than 20 msec sends the trigger (see Ping Synchronization Commands).

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). 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 than 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 than ping within 250 microseconds of the leading edge of the break pulse (See also FSA-018 - Triggering a DVL with a TTL Signal).

How can I synchronize with another sensor?

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

1. Set up 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?, first Triggering solution above).
2. Set up the system to be triggered via a short pulse through the RS485 serial lines (see Can I externally trigger the DVL?, and RDS3 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)).

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 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 31). 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 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.

> 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) or TT for Y2K compliant clock time (see TT – Set Real-Time Clock (Y2k Compliant)). 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). The travel time in water is dependent 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). 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.

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). 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). 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).

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 *TRDI Toolz*.

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

1. Run *TRDI Toolz*.
2. Select your device: WorkHorse.
3. Select the port parameters: COMx, baudrate (9600 baud is the factory default), Parity none, Stop Bits 1, Flow Control None.
4. Check "**send a break on new connection**" and "**send CK on baudrate changes**" (Optional).
5. Send a break by clicking on *TRDI Toolz* **Break** icon (⚡) 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) 1996-2010
All Rights Reserved.
```

6. Press the **F2** key on your keyboard and select the script file you want to send to the DVL.

7. *TRDI Toolz* sends each command included in the command file in the order they are in the file.

The last command overrides an identical command sent previously.

8. You can use the TurnKey mode (see CT - Turnkey Operation) 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.

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).

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). 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.

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

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.

Frequency	Maximum Altitude	Minimum Altitude
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 and BL - Water-Mass Layer Parameters commands to control this feature.

How accurately can I navigate with my DVL?

Navigator specifications are shown in Specifications.

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.

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, than 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, than no data will be outputted unless the EQ command is used to enable single beam data (see EQ – Enable Single Beam Data). However, if the structure interferes with three or four beams, than 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, than you must calibrate the biases due to the vehicle magnetic signature (see Compass Calibration). 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).

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

The Navigator is designed to cope with seabed slopes of up to 20° 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). 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.

> Always use the CK command in your configuration file (see Creating a Command File Using PlanADCP).

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, than beams 1 and 2 would isonify the bottom. If the pipe is large or the system is close to the pipe, than 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).

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, than the transmit pulse length is limited to 15% BX (see BX – Maximum Tracking Depth).

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). 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).

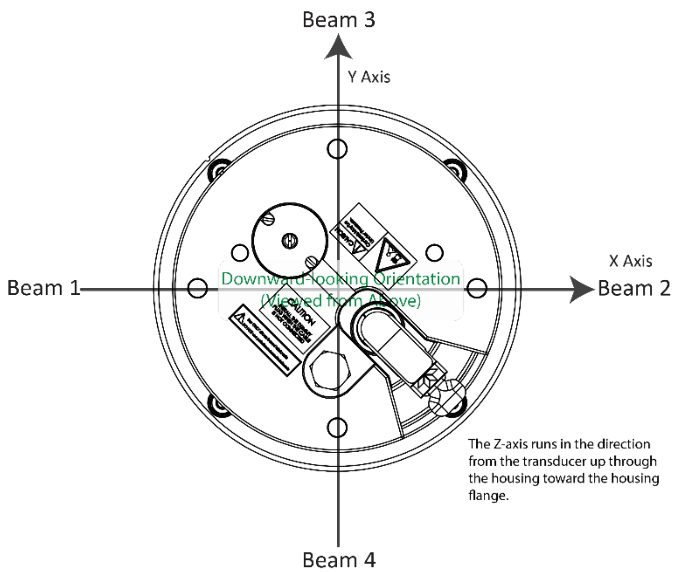
What Beam Coordinate System should I use and why?

The Navigator can produce velocity measurements in any of the following four sets of coordinate axes by setting the EX command. Except for the first, they are all right-handed orthogonal systems. The user operational requirements dictate the best coordinate system to be used.

Earth Axis, also known as Geographic or Geodetic Coordinates. (E, N, U) Earth Axis are selected (default setting) with command EX11xxx. These axes are named east, north, and up. Strictly speaking, these terms refer to true orientations, although magnetic orientations are often used instead. This is the most commonly used coordinate system because it provides a stable reference frame for ensemble averaging.

Radial Beam Coordinates. (BM1, BM2, BM3, BM4) Radial Beam Coordinates are selected by the EX00xxx command. These are the "raw" velocity measurements measured independently by each transducer, in units of millimeters per second. The sense is positive when the motion is towards the transducer. These axes are not orthogonal.

Instrument Coordinates. (X, Y, Z) Instrument Coordinates are selected by the EX01xxx command. This set of axes is always oriented the same relative to the transducer head. Looking at the end view of the housing, the transducers are labeled clockwise in the order 3-2-4-1 (Figure 18). When you look at the face of the transducer head, the transducers are labeled clockwise in the order 3-1-4-2 (see Figure 19, page 55). The X-axis lies in the direction from transducer Beam 1 towards transducer Beam 2 and the Y-axis lies in the direction from transducer Beam 4 towards transducer Beam 3. The Z-axis lies along the axes of symmetry of the four beams, pointing away from the water towards the housing. The internal compass is mounted so that when the X-Y plane is level, the compass measures the orientation of the Y-axis relative to magnetic north.



The PD0 Bottom Track output data format assumes that the instrument is stationary and the bottom is moving.

- If Beam 3 is going forward, then the Y velocity is negative.
- If Beam 2 is going forward, then X velocity is negative.
- If the bottom is going towards the face of a down facing DVL, then Z is positive.

The PD3 through PD6 data formats assume that the bottom is stationary and that the DVL or vessel is moving.

- If Beam 3 is going forward, then the Y velocity is positive.
- If Beam 2 is going forward, then X velocity is positive.
- If the bottom is going towards the face of a down facing DVL, then Z is negative.

Figure 18. X, Y, and Z Velocities

Ship Coordinates (or Righted Instrument Coordinates). (S, F, M) Ship Coordinates are selected by the EX10xxx command. TRDI uses the names Starboard, Forward, and Mast, although these axes are more commonly called the roll, pitch, and yaw-axes, respectively. Assuming that Beam 3 is aligned with the keel on the forward side of the DVL, for the downward-looking orientation, these axes are identical to the instrument axes:

$$S = X, F = Y, M = Z$$

For the upward-looking orientation, these axes are rotated 180° about the Y-axis:

$$S = -X, F = Y, M = -Z$$

The M (mast) axis points in a direction that is closer to upward than downward (mast is always in the same direction no matter if looking down or up).

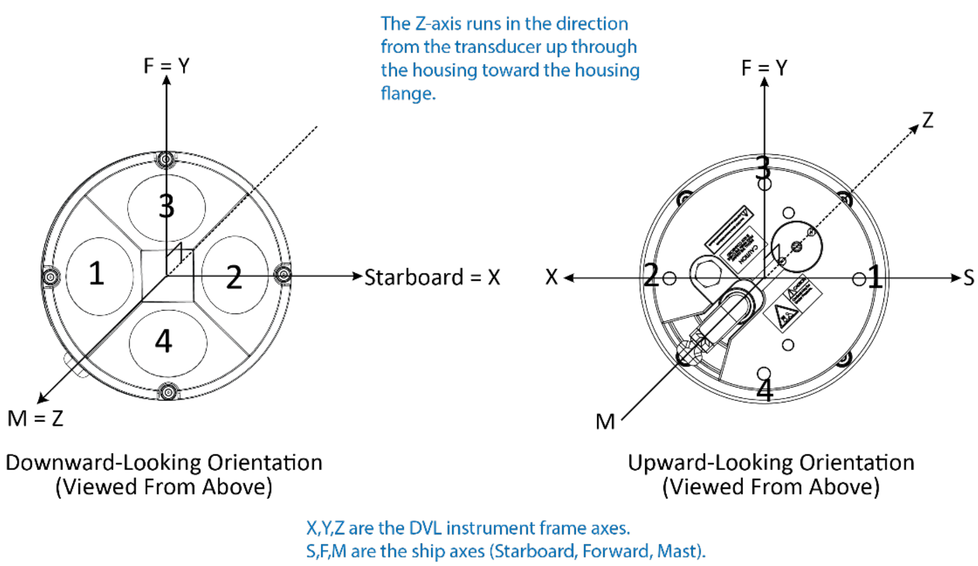


Figure 19. Navigator Ship Coordinates

The importance of the ship axis is that the attitude angles (pitch, roll, and heading) measure the orientation of the ship axes relative to the earth axes, regardless of up/down orientation. The sense of internal sensors Tilt 1 (pitch) and Tilt 2 (roll) is positive for counterclockwise tilts respectively about the S and F axes, using the right-hand rule (see Figure 20).

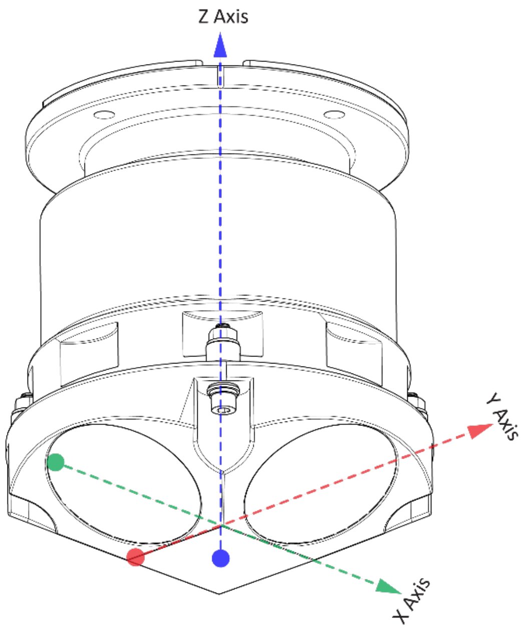


Figure 20. Navigator Pitch and Roll

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	+	-

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 section.

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

- **PD0** 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** 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** 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** 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** 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 not 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 Chapter 9 – Output Data Format.

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	✓							
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

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) assumes that the instrument is stationary and the bottom is moving.

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), 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 9.21:

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

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:

1. 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.
2. 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.
3. 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 DVL. If additional sensor data is to be added to the variable leader data, than it must be added to the end of the data string (bytes 54-x as an example).
4. 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.
5. The header data will include the number of data types in the files and the offset to each ID number for each data type.
6. 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, than you have located the Header ID. If not, than 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 its 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 and BL - Water-Mass Layer Parameters 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.

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?

1. For each ping, the ADC samples the pressure sensor five times and averages the data. This is an attempt to reduce the Standard Deviation.
2. Using the Pressure coefficients, the pressure data from the ADC is converted to kPa.
3. 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.
4. 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/Fresh Water Density))/10

NOTES

Chapter 4

MAINTENANCE

In this chapter, you will learn:

- Where parts are located on the DVL
- How to spot problems
- How to take the DVL apart and put it back together
- How to do periodic maintenance items on the DVL

Parts Location Drawings

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

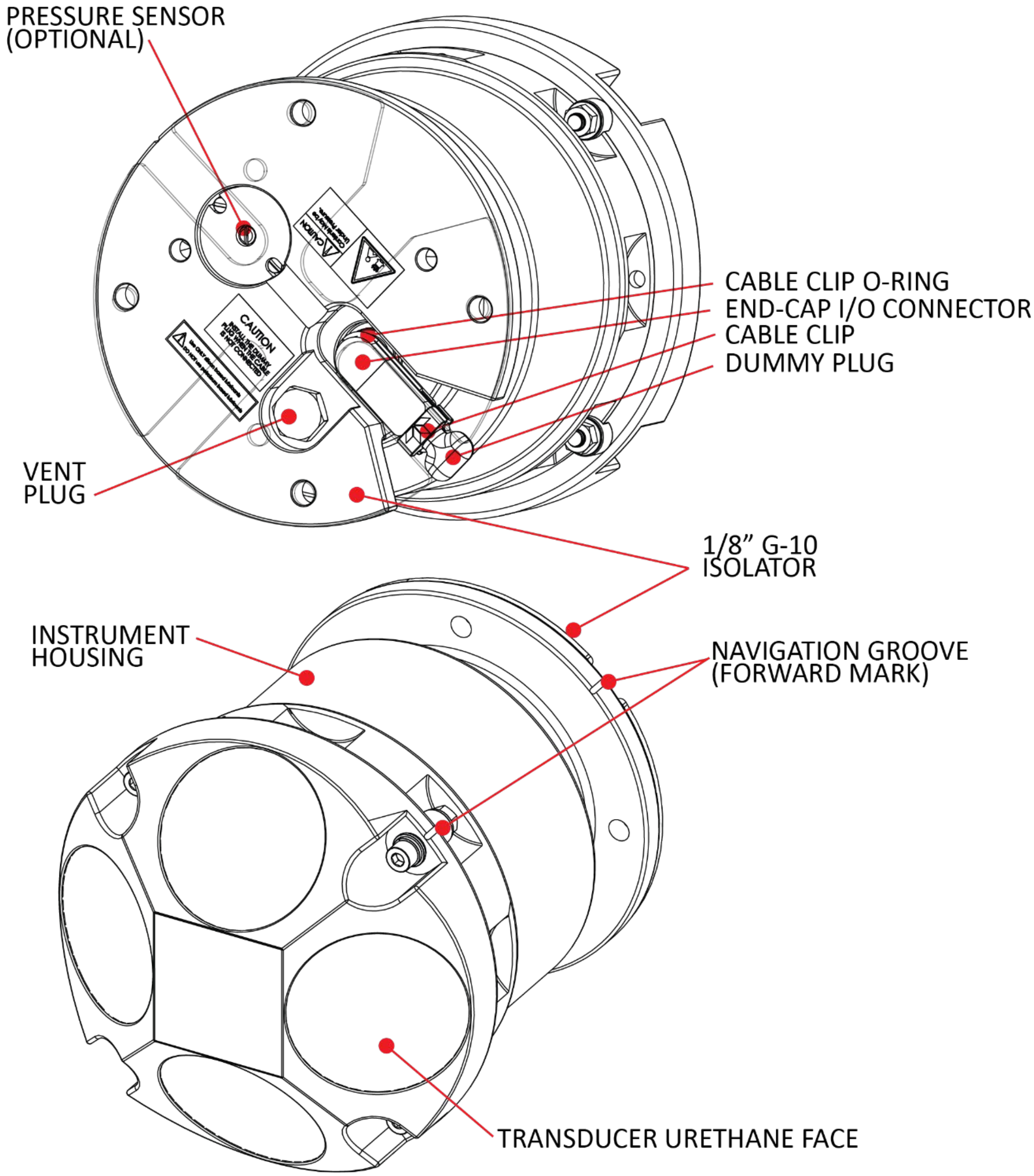


Figure 21. Navigator External Parts Location

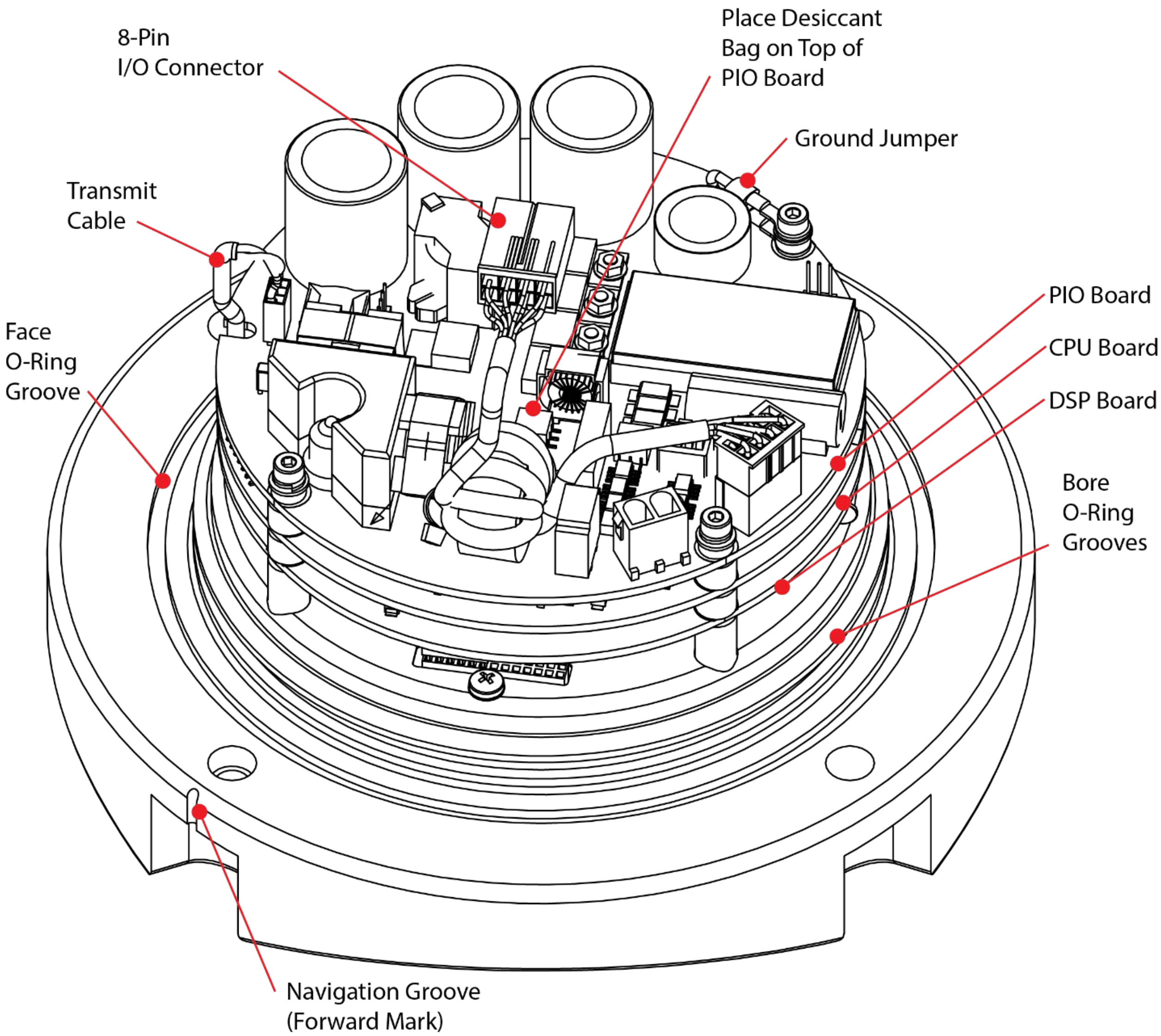


Figure 22. Navigator Internal Parts Location

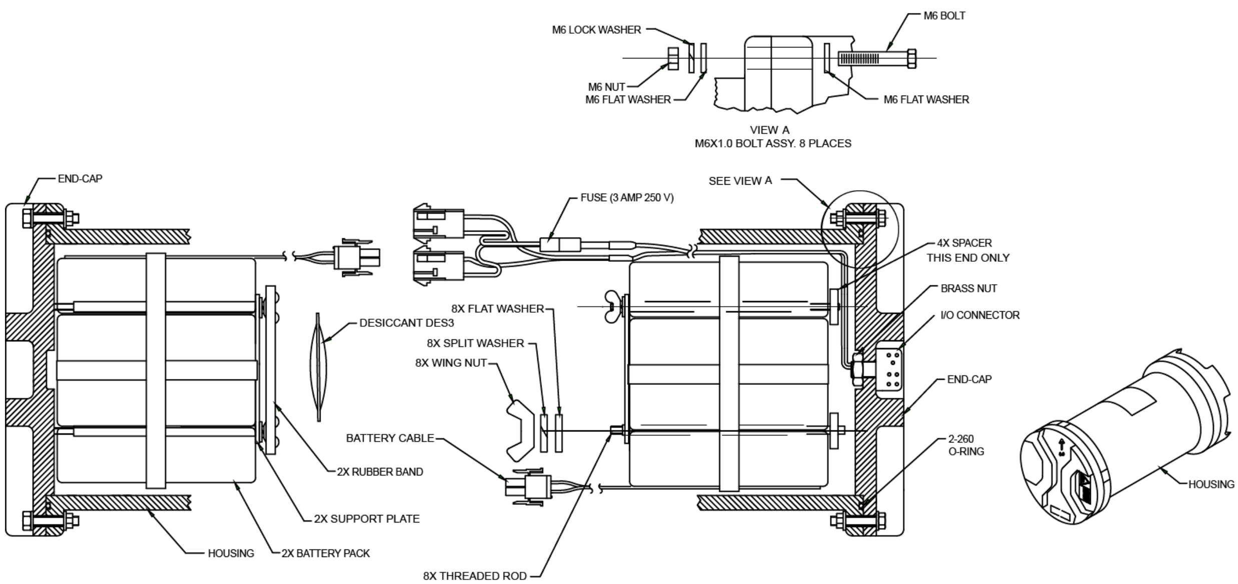


Figure 23. External Battery Pack Parts Location

Maintenance Schedule

To ensure that you continue to receive optimal results from your Teledyne RD Instruments product(s), TRDI recommends that every DVL be returned to our factory for an inspection every two to three years. We'll provide your unit with a thorough multi-point inspection, and let you know if any refurbishment services are required to properly maintain the unit. To learn more about this service, please contact field service.

Calibration Items

The accuracy of the sensors used withon the DVL wll change over time due to physical aging effects. For example, the pressure sensor has an initial accuracy spec of ±0.25%, and the accuracy of the pressure sensor will degrade by an additional ±0.11% over time due to long term drift. The fluxgate compass accumulates an error of approximately 1% over a year. These sensors should be periodically checked for accuracy to ensure their accuracy is still within specification for the target application. These verifications can be performed in a suitable laboratory facility or at the TRDI factory. If any items are outside of specification due to long-term drift they should be returned to the factory for recalibration.

TRDI recommends a verification of sensor performance every two to three years for the following items:

Item	TRDI Recommended Period
Transducer Beam Angle	Verification of system horizontal velocity accuracy.
Pitch & Roll (Tilt)	Verification of measured pitch and roll versus reference standard.
Temperature Sensor	Verification of measured temperature versus reference standard.
Pressure Sensor	Verification of measured pressure versus reference standard.
Fluxgate Compass	Verification of measured heading (after field calibration) versus reference standard.

In addition to the above verifications, note that the compass should always undergo a field calibration (see Compass Calibration) prior to deployment and a field verification after deployment (see Compass Calibration Verification).

Maintenance Items

Inspect the Navigator to spot problems:

Item	TRDI Recommended Period
Transducer Beams	The urethane coating is important to DVL watertight integrity. Many users are not familiar with the early signs of urethane failure. The primary damage to the urethane is from bio-fouling and long exposure to the water and sun. Damage occurs on the surface of the urethane and at the edge where the urethane bonds to the cups. Mishandling, chemicals, abrasive cleaners and excessive depth pressures can also damage the transducer ceramics or urethane coating. Before each deployment, check the urethane coating on the transducer faces for dents, chipping, peeling, urethane shrinkage, hairline cracks and damage that may affect watertight integrity or transducer operation (see Figure 24). **Based on experience, TRDI knows that most systems need to have the urethane inspected after three to five years of field use; shorter periods may be required depending on marine growth.**
O-rings	O-rings should be replaced whenever the system is opened and BEFORE they are showing any signs of wear and tear. **All O-rings should be replaced every one to two years maximum.**
Housing and End Cap	**Inspect for damage and replace as needed before each deployment.** Inspect the paint on 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 WorkHorse depends on it.** See Protective Coating Inspection and Repair for details.
Hardware (bolts, etc.)	Check all bolts, washers and split washers for signs of corrosion before each deployment. **TRDI recommends replacement after every deployment or every year whichever is longer.** Damaged hardware should never be used.
Zinc Anodes	Inspect the anodes (available on aluminum systems only) before each deployment for wear around the mounting bolts. Cover bolts with silicone sealant prior to deployment. Replace anodes whenever the mounting bolt is in less than 75% in contact with the bolt. **Replace all anodes every one to two years maximum.**
Cables and Connectors	Check the end-cap I/O connector for cracks or bent pins (see Figure 25) before each deployment. **Replace the end-cap I/O connector every five years as a normal maintenance item** (see Table 13. Replacement Kits to order parts). Check the cable connectors for cracks or bent pins. Inspect the full length of the cable for cuts, nicks in the insulation, and exposed conductors before each deployment. Check the Deck Box (Mariner) connectors on the rear panel for cracks or bent pins. Repair of the Deck Box connectors should only be done by TRDI.
CPU Lithium Coin-Cell Battery	TRDI recommends replacing the lithium coin-cell battery **every five years.**

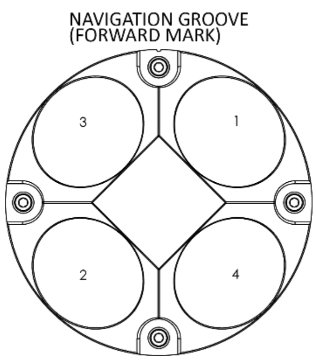


Figure 24. Transducer View

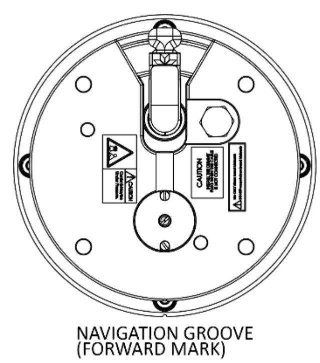


Figure 25. End-Cap View

Replaceable Parts

Table 12: Navigator Replaceable Parts

Part Number	Item Name	Where Used
206062-1	Clamp, Cable, Plastic Shell	AC Power Adapter
206430-2	Receptacle, 4 Pin, Free Hang	
66101-4	Socket, Crimp, 18-16AWG	
SPR84-1LB	Rubber Band	Battery pack
5020	Silicone Lubricant, 4-Pack	Housing
75ZK6001-00	Kit, Clip, Cable	
75ZK6001-01	Kit, Clip, Dummy Plug	
97Z-6084-00	O-Ring, 2-015, .070DIAX.551 ID, EPDM, DURO 90A, Vent Plug	
97Z-6084-01	O-Ring, 3-094, .072DIAX.351 ID, EPDM, DURO90A, Vent Plug	
97Z-4001-00	Plug, Vent, External Hex Head, TI	
97Z-6050-00	O-Ring, 2-258, 70 DURO, EPDM	
97Z-6053-00	O-Ring, 2-261 DURO 70, EDPM	
97Z-6068-00	O-Ring, Back-Up Ring Bore Seal, DURO 90	
810-4006-00	Anode, Housing Flange, 3000/6000M	
811-4007-00	Bushing (300/600 kHz)	
305D0010	Bushing, Instrument Housing (300/600 kHz)	
M8WASHSPL	Washer, Split Lock, SST316 (300/600 kHz)	
M8WASHSTD	Washer, Flat, 16mm OD, SST316 (300/600 kHz)	
M8X1.25NUT	Nut, Hex, SST316 (300/600 kHz)	
M8X1.25X45SH	Screw, SKT HD, SST316 (300/600 kHz)	
M6WASHNYLON	Washer, Flat, 6.4 ID 12.5 OD, NYLON (1200 kHz)	
M6WASHSMOD	Washer, Flat, 11mm OD, SST316 (1200 kHz)	
M6WASHSPL	Washer, Split Lock, SST316 (1200 kHz)	
C28022	Insulator	
M6X1.0NUT	Nut, Hex, SST316 (1200 kHz)	
M6X1.0X35SH	Screw, SKT HD, SST316 (1200 kHz)	
GMA-3A	Fuse, 5mm X 20mm 3R 250V	Main Electronics
717-3008-00	Jumper, GND	
817-3003-00	Washer, Felt	
DES3	Desiccant, Sealed Bag	Inside Housing
817-1067-00	Screw, Pressure Sensor	Pressure Sensor

Table 13. Replacement Kits

Part Number	Description	Where Used
757K6122-00	WorkHorse End-Cap Tools Kit	Replacing the End Cap Connector
757K6125-00 (6000 meter systems)	End Cap Connector Replacement Kit (requires the WorkHorse End-Cap Tools Kit)	
757K6149-00 (WorkHorse External Battery case)		
757K6023-00	Battery Pack Kit (includes 1 battery, desiccant, and 2 rubber bands)	Replacing the External Battery Case Packs
717-3009-00	Battery Packs (10-pack)	
757K6035-02	1200 kHz Spare Boards Kit	Installing the Spare Boards Kit
757K6035-03	600 kHz Spare Boards Kit	
757K6035-04	300 kHz Spare Boards Kit	
757K6088-00	300 and 600 kHz Spare Parts and Tools Kit	Periodic maintenance and spare parts
757K6089-00	1200 kHz Spare Parts and Tools Kit	
757K6090-00	1200 kHz 3000/6000 meter Close-Up Kit	Includes all O-rings, desiccant, and a complete set of transducer mounting hardware
757K6093-00	300/600 kHz 3000/6000 meter Close-Up Kit	

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.

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

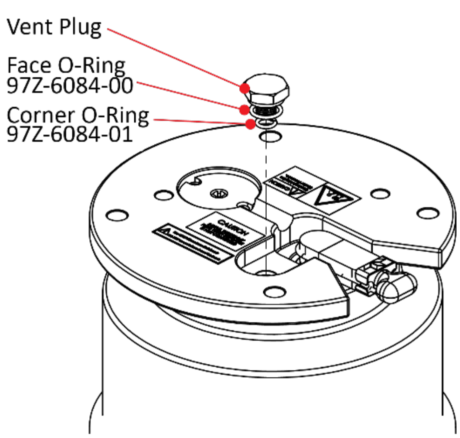
Housing Removal

Caution label on housing

Wear safety glasses and keep head and body clear of the housing while opening. Any system that was deployed may have pressure inside the housing.

To remove the housing:

1. Remove all power to the Navigator.
2. Remove the I/O cable and install the dummy plug (see I/O Cable and Dummy Plug).
3. Stand the Navigator on its transducer faces on a soft pad.
4. Inspect the housing and the four bolts (8-mm for 300/600 kHz systems and 6-mm for 1200 kHz systems) that attach the housing flange to the transducer head assembly for any signs of damage such as bending, stretched bolts, crushed or deformed bushings, etc. These signs may indicate that there is internal pressure inside the system.
5. To avoid any possible injury it is **ALWAYS** recommended to loosen but do not remove the Vent Plug to allow any internal pressure to be vented from the system. Use a 7/8 socket wrench to loosen the Vent Plug slowly ½ turn at-a-time until the corner O-ring on the Vent Plug is not compressed and the system has the opportunity to vent. **Be sure to only loosen the Vent Plug far enough to allow the system to vent.**



If the system does not include a vent plug, loosen all four housing bolts two turns each until the face seal O-ring is not compressed and the system has the opportunity to vent.

6. Once the Vent Plug has been loosened and you are sure that there is no internal pressure, remove the plug from the housing. Remove the corner Vent Plug O-ring.
7. Loosen all four housing bolts and than remove the bolts from the transducer head assembly.
8. 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.

> 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.

9. 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.
10. Clean the O-ring mating surfaces with a soft, lint-free cloth. Inspect the surfaces for damage (see O-ring Inspection and Replacement).
11. When you are ready to re-assemble the Navigator, see Navigator Re-assembly.

Navigator Re-assembly

Use Parts Location Drawings for parts identification.

To replace the housing:

1. 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).
2. Make sure all printed circuit boards, spacers, cables, and screws have been installed.
3. Inspect/replace the O-rings before closing the Navigator (see O-ring Inspection and Replacement).
4. Install two fresh bags of desiccant just before closing the Navigator (see Desiccant Bags).

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 for the locations of the following O-rings and Table 12 for part numbers. Read all instructions before doing the required actions.

Part Number	Description
97Z-6050-00	Bore O-Ring, 2-258, 70 DURO, EPDM
97Z-6053-00	Face O-Ring, 2-261 DURO 70, EDPM
97Z-6068-00	O-Ring, Back-Up Ring Bore Seal, DURO 90
97Z-6084-00	O-Ring, Vent Plug, 2-015 .070DIAX.551 ID, EPDM, DURO 90A,
97Z-6084-01	O-Ring, Vent Plug, 3-094, .072DIAX.351 ID, EPDM, DURO90A,

> 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 26).

TRDI strongly recommends 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.

TRDI recommends you use new O-rings if you are preparing for a deployment.

5. 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 than 0.1 mm (0.004 in.).

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

6. 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.

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

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

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.

8. The backup O-ring (see Figure 26) 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.

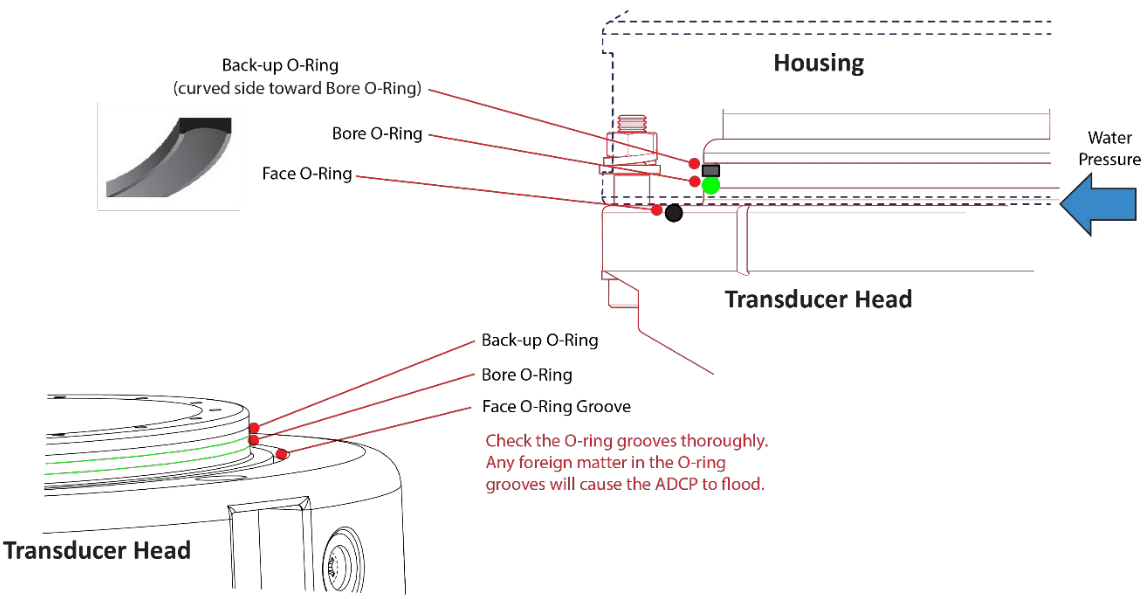


Figure 26. O-Ring Detail View

Housing Assembly Replacement

To install the housing:

1. Stand the Navigator on its end-cap/mounting flange.
2. Inspect, clean, and lubricate the O-rings on the housing (see O-ring Inspection and Replacement). Apply a very thin coat of silicone lube on the O-rings.

> TRDI recommends you use new O-rings if you are preparing for a deployment.

> 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.

3. Connect the internal I/O connector to the plug on the common mode choke.
4. 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.

> 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.**

5. Examine the transducer assembly and housing for damaged paint around the transducer mounting hardware; repair as necessary.
6. Examine the transducer assembly nuts, bolts, and washers (8-mm for 300/600 kHz systems and 6-mm for 1200 kHz systems) for corrosion; replace if necessary. Figure 27 and Figure 28 show the assembly order of the transducer mounting hardware. All hardware items are needed to seal the Navigator properly.

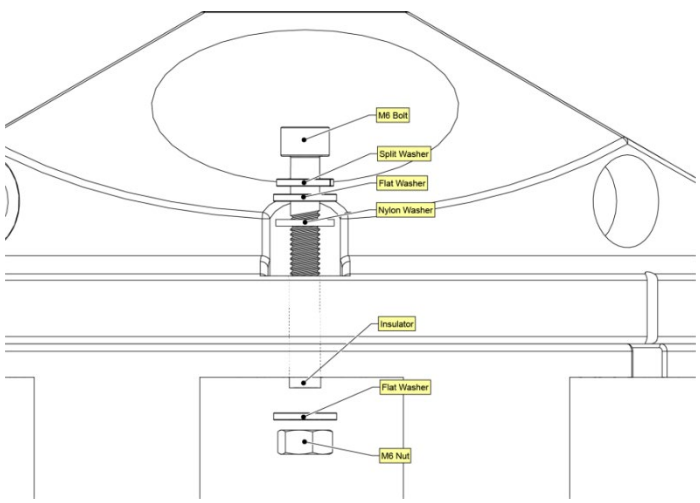


Figure 27. Transducer Mounting Hardware – 1200 kHz

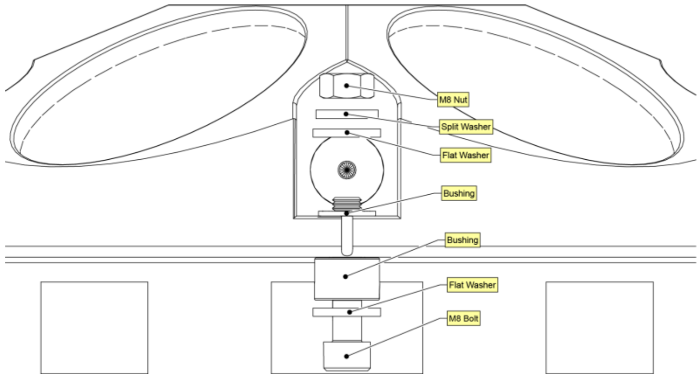


Figure 28. Transducer Mounting Hardware – 300/600 kHz

7. Install all four sets of hardware until "finger tight."
8. 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) for M8 bolts or 5.6 Newton-meters (50 pound-inches) for M6 bolts. Do not deform the plastic bushings.

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

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 of 9.6 Newton-meters (85 pound-inches) for M8 bolts or 5.6 Newton-meters (50 pound-inches) for M6 bolts.**

9. Lubricate and inspect the Vent Plug O-rings. Place the corner Vent Plug O-ring so that it rests on the bottom of the vent plug hole. Check the face Vent Plug O-ring is in the groove on the plug.
10. Install the Vent plug until "finger-tight."
11. Tighten the Vent Plug to the recommended torque value of 6.8 Newton-meters (60 pound-inches).

Periodic Maintenance Items

Periodic maintenance helps keep the Navigator ready for deployments.

Desiccant Bags

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

As a minimum, replace the desiccant bags (Table 12) whenever you are preparing to deploy or store the DVL for an extended time.

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

Do not puncture or tear the desiccant bag. Do not use desiccant bags that are torn or open.

Desiccant bags are shipped in a zip lock bag to ensure maximum effectiveness. TRDI recommends replacing the desiccant bag just before the deployment.

The desiccant should be replaced on a yearly basis or whenever the system is recovered from a deployment.

To replace the desiccant:

1. Remove the housing (see Navigator Disassembly).
2. Remove the new desiccant bags from the airtight aluminum bag.
3. Remove the old desiccant bags and install two new ones. Place the desiccant bags (Table 12) between the PIO board and the end-cap.
4. Install the transducer head (see Navigator Re-assembly).

Cleaning the Pressure Sensor Port

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 29 to clean the screw.

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

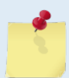
To clean the port:

1. Place the DVL on its' face. Use a soft pad to protect the DVL.
2. Lift off the G-10 Isolator plate.
3. Use a straight-slot screwdriver to remove the two nylon M3 screws. Lift the plastic cover up.
4. 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).
5. Look for signs of corrosion around the pressure sensor such as white deposits. If corrosion caused part of the pressure sensor housing to be visibly damaged, do not redeploy your system. Send it back to TRDI for inspection (see Returning Systems to TRDI for Service).

6. Clean both M3 screw mounting holes with a thin brush and lime based product. Flush the holes with the lime based product if you do not have a brush available. Be sure to clean and remove any signs of corrosion.
7. Brush the M3 screws with marine environment grease such as Aqua Shield grease. Use gloves as it tends to stick to your skin. Note that the grease is incompressible and therefore apply a thin layer to the screws to avoid binding or difficulty in the installation of the screws in the mounting holes.
8. Install the copper screw and cover. Tighten the screws "finger tight" (2 in/lbs). Do not over tighten the screws or you may strip the threads on the plastic cover disc or break the nylon M3 screws. If this happens, return the DVL to TRDI for repair.

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

Do not attempt to clean the surface of the pressure sensor. The diaphragm is very thin and easy to damage. If the pressure sensor surface looks corroded or is bowed outward, then contact TRDI for servicing.



The pressure sensor installed on the DVL is installed in a cavity that includes a protective cover to prevent particles from collecting on top of the pressure sensor itself. This cover is made of plastic and is held into place with two M3 screws. The holes where the M3 screws are inserted in the housing are anodized aluminum.

TRDI knows from our experience that it is difficult to anodize sharp edges on threaded holes such as these. In marine and fresh water environments, poor anodizing on aluminum will lead to corrosion problems. Always inspect for corrosion in this (and all) areas between deployments.

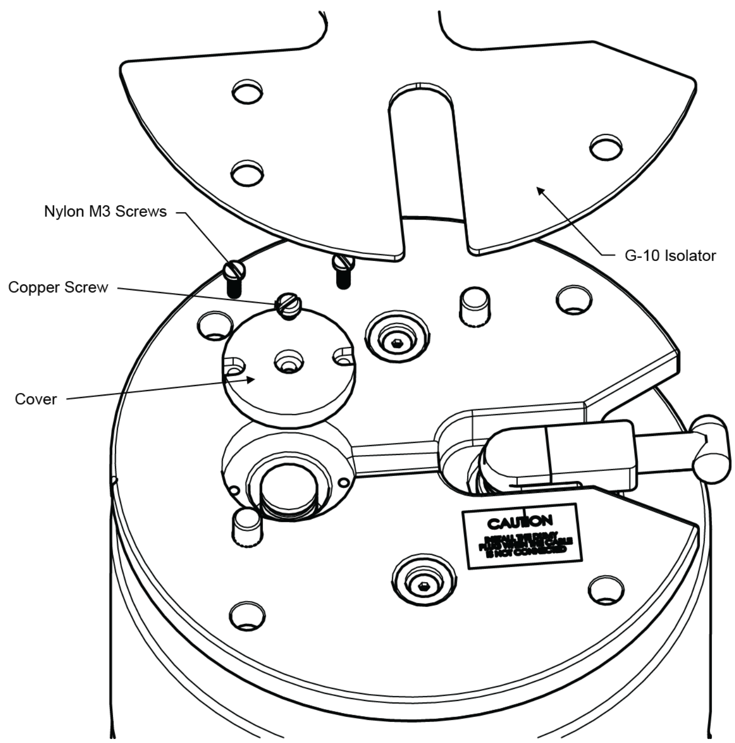


Figure 29. Navigator Pressure Sensor

Protective Coating Inspection and Repair

TRDI uses paint on the high pressure housing for identification and corrosion protection. For more protection, the case and the transducer assembly are first anodized per MIL-A-8625, Type 3, Class 1 and sealed with sodium dichromate. Do not damage the surface coatings when handling the Navigator.

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 (light blue or yellow for 6000 meter systems). **Be critical in your judgment; the useful life of the DVL depends on it.**

The procedures contained in this section apply to our standard aluminum systems. For systems made of other materials, contact TRDI. Read all instructions before doing the required actions.

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.

If there is any damage to the paint near the edges of the urethane transducer cups or the I/O connector, DO NOT DEPLOY THE DVL. Return the DVL to TRDI for repair.

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 there is damage to the anodizing, return the DVL to TRDI for repair.
2. Clean the area with alcohol. Do not touch the area after cleaning.
3. Mix the epoxy primer Part A and Part B using a 1:1 mix. Paint one coat of epoxy primer (see note below). Allow the primer to dry thoroughly before continuing.
4. Mix the colored paint using two parts color and 1 part catalyst. Paint with one coat of colored paint (see note below).

The catalyst (hardener) will rapidly harden in air. Mix only the amount of paint you need and work quickly.

TRDI uses two-part epoxy type paint. This paint is manufactured by Sherwin –Williams Proline Paint Store, 2426 Main St., San Diego, CA, 92113-3613, Telephone: +1 (619) 231-2313.

Primer Manufacturer's part numbers:
F-158 for 6000 meter systems (part A and part B)
3061 for all other systems (part A and part B)

Colored paint Manufacturer's part numbers:
4800HS, Catalyst,
4800-01, Snow White
4800-19, Yellow
4800-25, Bright Blue
4800-28, Orange
4800-29, Marine Red (standard Navigator color)

Contact the paint manufacturer for preparation and application procedures for this and other paints. Contacting this company is done with the knowledge that Teledyne RD Instruments is not recommending them, but only offering this as a source for the paint.

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.

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.

To inspect the anodes:

1. Inspect the anodes on the housing for corrosion and pitting. If most of an anode still exists, you may not want to replace it.
2. 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.
3. If you have doubts about the condition of the anodes, remove and replace the anode.

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.

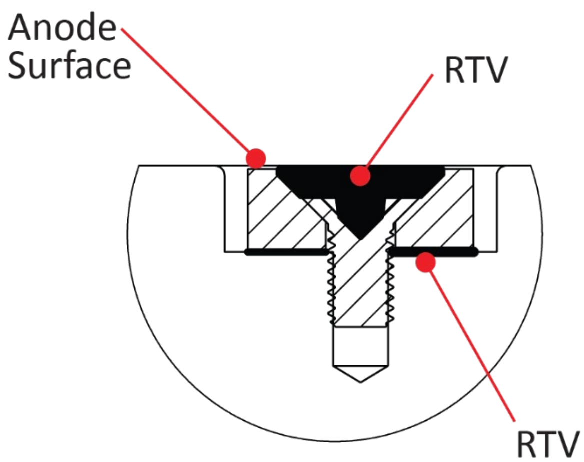
Housing Anodes. Measure the resistance between both anodes. Scratch the surface of the anode with the DMM probe to make good contact if the anode is oxidized. The resistance should be less than five ohms.

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.

Zinc Anode Replacement

To remove and replace the zinc anode/s:

1. Remove the RTV from the anode screw heads. Remove the screws.
2. 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.
3. Clean the bonding area under the anode. Remove all foreign matter and corrosion. Look for signs of corrosion such as white deposits. If corrosion caused part of the housing to be visibly damaged, do not redeploy the system. Send it back to TRDI for inspection (see Returning DVLs to TRDI for Service). Clean the mounting hole with a thin brush and lime based product. Flush the hole with the lime based product if there is no brush available. Be sure to clean and remove any signs of corrosion.
4. Apply a thin bead of RTV sealant around the edge of the threaded anode mounting hole.



5. Set the new anode in place and tighten the screw to 1.7 ± 0.2 N-M (15 ± 1.5 IN-LB).
6. Fill the counter bore above the screw head with RTV. Pop any air bubbles in the RTV and wipe off any excess RTV at the base or on top of the anode (**the anode must contact seawater**). The RTV protects the screw heads from water and prevents breaking the electrical continuity between the anode, screw, and housing. Allow the RTV to cure for two hours at room temperature.

Do not cover the top surface of the anode with RTV. The anode must contact seawater.

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

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.

Do not connect other metal to the Navigator. Other metals may cause corrosion damage. Use isolating bushings when mounting the system to a metal structure.

Compass Calibration

Navigator compass calibration corrects for distortions in the earth's magnetic fields caused by permanent magnets or ferromagnetic materials near the Navigator. These magnetic field distortions, if left uncorrected, will create errors in the heading data from the Navigator. A compass calibration should be conducted at each measurement location, and whenever the mounting fixture, boat, or ancillary equipment such as batteries or radios are changed or rearranged. Be aware of the following items:

- Compass calibration is especially important when using the Navigator on a UAV as they often have significant magnetic field distortions from the hull, engine(s), and ancillary equipment. Accurate calibration may not be possible in extreme cases.
- If the 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.
- Ferromagnetic structures such as bridges or sheet piling in the measurement location may interfere with proper compass operation. The compass calibration procedure can NOT correct for heading errors due to these types of structures.

Compass Background

The compass calibration algorithm collects magnetic field vector information for various measured headings during the calibration. Hard and soft iron effects rotating with the compass are made observable during the calibration by causing the local field to be perturbed as the compass is spun during the calibration. That is, each component of the hard and soft iron has to alternately increase the local field for some orientations and decrease for orientations 180 degrees (or 90 degrees for soft iron) from those orientations for the algorithm to "notice" it. Tilting and rotating the compass about the vertical axis is sufficient to do this.

There are two compass calibrations to choose from; one only corrects for hard iron while the second 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.

Preparing for Calibration

To prepare for a compass calibration:

1. 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.

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

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.

2. Connect the Navigator as shown in Figure 2.
3. Start *TRDI Toolz*. See the RDI Tools User's Guide for assistance on using *TRDI Toolz*.

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 5° of rotation for a full 360° rotation. When it has collected data for all required directions, the Navigator computes and displays the results.

To verify the compass calibration:

1. Prepare the DVL for calibration (see Preparing for Calibration).
2. Using *TRDI Toolz,* send a Break to wake up the Navigator.
3. At the ">" command prompt enter **AX** and press the return key.
4. 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).

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.

To calibrate the compass:

1. Prepare the DVL for calibration (see Preparing for Calibration).
2. Using *TRDI Toolz,* send a Break to wake up the DVL.
3. At the > prompt, type **AR** and press the **Return** key. This will return the compass to the factory calibration matrix.
4. At the > prompt, type **AF** and press the **Return** key. Choose option "a" or "b" to start the calibration procedure.

```
>af

------------------------------------------------------------------------------
                         Field Calibration Procedure
Choose calibration method:
     a.  Remove hard iron error (single cycle) only.
     b.  Remove hard and soft iron error (single + double cycle).
     c.  Help.
     d.  Quit.
```

> In general, the hard iron calibration is recommended for Navigator systems because the effect of hard iron dominates soft iron.
>
> For systems that have just replaced the battery, then use the combined hard and soft iron calibration. Changing the batteries should only change the hard-iron signature of the DVL, but can induce both single and double cycle compass errors.

5. Tilt the DVL (see Figure 30). 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.

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

6. When prompted, rotate the DVL slowly 360 degrees (approximately 5 degrees per second).
7. The second rotation requires the DVL to be tilted 15 degrees in another direction than from the first rotation (see Figure 30). Follow the on-screen instructions to orient the DVL correctly. When prompted, rotate the DVL slowly 360 degrees (approximately 5 degrees per second).
8. 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.
9. 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.
10. If the calibration procedure is not successful, return the 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.

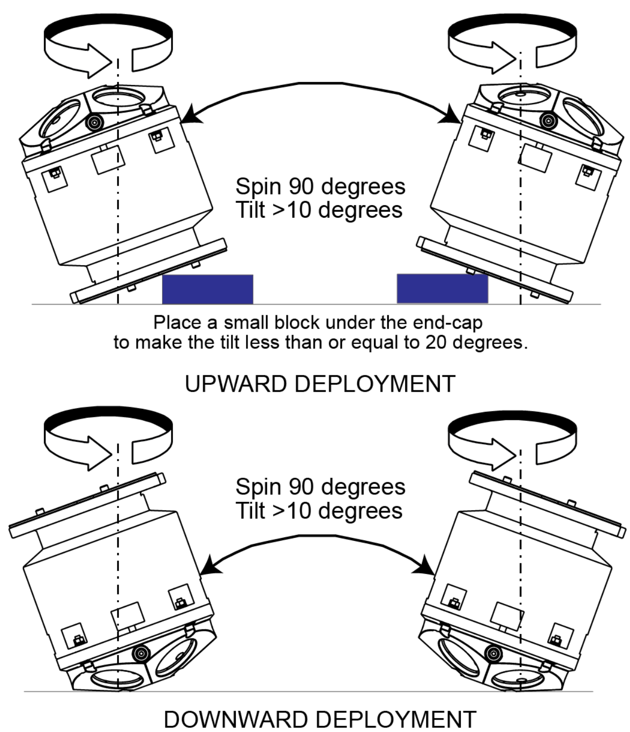


Figure 30. Compass Calibration

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 water. This means DVL systems are subject to biofouling. 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 DVL. Therefore, you should take steps to prevent biofouling during shallow water deployments.

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. If using antifouling grease, remove the grease immediately after recovering the DVL from its deployment. Remove the grease with soapy water because cleaning solvents may also cause the urethane to crack. Be sure to wear protective gloves and a face shield.

The best-known way to control biofouling is cleaning the DVL transducer faces often. However, in many cases this is not possible.

The following options can help reduce biofouling:

- Coat the entire DVL with antifouling paint. Make sure that the paint is applied in an even coat over the transducer faces and inductive modem (see Applying Antifouling Paints).
- Apply a thin coat (1 mm, 0.039 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.
- If using antifouling grease, remove the grease immediately after recovering the DVL from its deployment. Remove the grease with soapy water. Be sure to wear protective gloves and a face shield.

If using antifouling grease, remove it immediately after recovering the DVL.

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.

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.

Antifouling Paints

You can use almost any EPA approved anti-fouling paint on the housing or the urethane transducer faces. Contact the antifouling paint manufacturer for preparation and application procedures for this and other antifoulant paints. Interlux is one source of antifouling paint. Contacting this company is done with the knowledge that Teledyne RD Instruments is not recommending them, but only offering this as a source for the anti-fouling paint.

Manufacturer	Contact
Courtalds Finishes	Telephone: +1 (800) 468-7589
Interlux brand paints	Web Page : http://www.yachtpaint.com/usa/

Do not use antifouling paints that contain cuprous oxide on aluminum as it will cause galvanic corrosion.

Applying Antifouling Paints

The following tips are only general recommendations. Always follow the anti-fouling paint manufacturer's instructions on how to apply the anti-fouling paint.

TRDI recommends that any antifouling coating should be applied in as thin a layer as possible. It should be understood that applying a coating may reduce the measurement range of the DVL (though it will not affect its accuracy in the measurable range).

As originally manufactured, the transducer faces have a smooth surface which makes it inhospitable for most biofouling to develop. Preserving this smooth surface is an effective way to prevent heavy biogrowth on the transducer faces. However, if an antifouling coating is desired on the transducer faces, then the faces must be lightly abraded to allow for the antifouling coating to adhere. **As a rule, the surface must be kept smooth unless an antifouling coating will be applied.**

To apply antifouling paint:

1. Transducer Face Surface Preparation - Lightly abrade the surface using Scotch Brite® to remove gloss. Thoroughly clean the areas to be painted with soapy water and dry.
2. Surface Application:
   - Mask as necessary to avoid having the antifouling paint come in contact with any bare metal surfaces.
   - Apply an even, thin layer (0.1mm, 4mil per coat) of antifouling paint. If more than one coat is needed to reach the maximum thickness, allow each coat to dry for 16 hours.
   - When applying paint to the urethane faces, use extra caution to apply a smooth, thin coat of paint.

Removing Biofouling

To remove foreign matter and biofouling:

1. Remove soft-bodied marine growth or foreign matter with soapy water. Waterless hand cleaners remove most petroleum-based fouling.

   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. The urethane coating on the transducer faces could be damaged.

   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 DVL operation, but TRDI does 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.

   If barnacles have entered more than 1.0 to 1.5 mm (0.06 in.) into the transducer face urethane, you should send the DVL to TRDI for repair. If you do not think you can remove barnacles without damaging the transducer faces, contact TRDI.

2. Rinse with fresh water to remove soap or Lime-Away® residue.
3. Dry the transducer faces with low-pressure compressed air or soft lint-free towels.

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

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.

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.

1. Remove one end-cap from the external battery pack (see Figure 23).
   a. Inspect the end-cap bolts for any signs of damage such as bending, stretched bolts, crushed or deformed bushings, etc. These signs may indicate that there is internal pressure inside the unit.

Wear safety glasses and keep head and body clear of the housing while opening. Any system that was deployed may have pressure inside the housing.

b. To avoid any possible injury it is **ALWAYS** recommended to loosen but do not remove the Vent Plug to allow any internal pressure to be vented from the system. Use a 7/8 socket wrench to loosen the Vent Plug slowly ½ turn at-a-time until the corner O-ring on the Vent Plug is not compressed and the system has the opportunity to vent. **Be sure to only loosen the Vent Plug far enough to allow the system to vent.**

If the external battery does not include a vent plug, loosen all four end-cap bolts two turns each until the face seal O-ring is not compressed and the system has the opportunity to vent.

   c. Once all four bolts (8-mm) have been loosened and you are sure that there is no internal pressure, remove the bolts from the end-cap.
2. Place the external battery case on its side and carefully pull out the battery pack (attached to the end-cap).
3. Disconnect the battery power cable from the wiring harness.
4. Remove the four wing nuts, lock washers, and washers holding the battery pack onto the posts (see Parts Location Drawings).
5. Remove the support plate.
6. Slide out the used battery pack.
7. 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.
8. Position the support plate over the four posts.
9. Place a flat washer, lock washer, and wing nut on each of the four posts. Tighten the nuts to hold the battery in place.
10. 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.

11. Connect the battery power cable to the wiring harness.
12. Install the end-cap/battery pack assembly.
13. Repeat steps "1" through "12" to replace the other battery pack.
14. Replace the desiccant bags on each battery just before sealing the external battery case (see Desiccant Bags).

Maintenance Procedures

Use the following procedures when performing maintenance tasks.

Replacing the Fuse

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).

To replace the fuse:

1. Turn off the power.
2. Remove the housing (see Navigator Disassembly).
3. 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.
4. Gently pull the fuse housing out. Turn the housing to remove the fuse.
5. Check the fuse using an ohmmeter. Replace the fuse if necessary with the correct voltage and amperage fuse (Table 12).
6. Install the housing (see Navigator Re-assembly).
7. Test the system (see Testing the Navigator).

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.

1. Remove one end-cap from the external battery pack.
2. Carefully lift out the battery pack (attached to the end-cap).
3. Check the fuse using an ohmmeter. Replace the fuse if necessary with the correct voltage and amperage fuse (Table 12).
4. Install the end-cap.
5. 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.

Changing the Communications Setting

A switch on the PIO board (see Figure 31) 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 a RS-232-to-RS-422 converter if the Navigator is using RS-422 communications and your computer only has an RS-232 COM port.

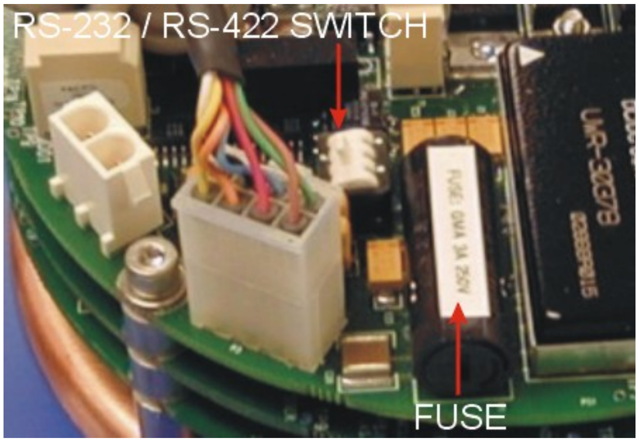


Figure 31. Communication Switch and Fuse

Replacing the PC Card Recorder

Navigator DVLs can use an optional memory card. The maximum memory for each slot is 2GB, with the total memory capacity not to exceed 4GB.

The optional PC Card recorder is located on the Digital Signal Processor (DSP) board inside the Navigator's electronics (see Figure 32). 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:

1. Turn off power to the Navigator.
2. Remove the housing (see Navigator Disassembly).
3. 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.

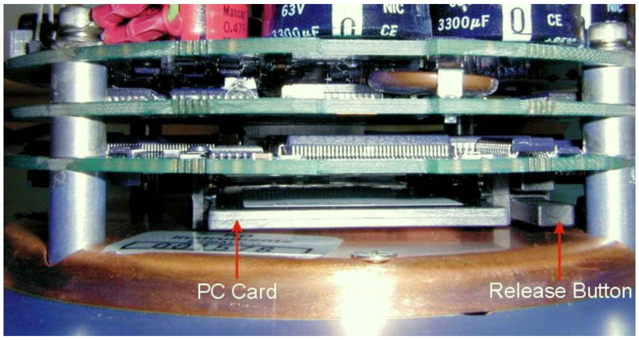


Figure 32. PC Card Recorder

4. 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.
5. Install the Housing (see Navigator Re-assembly).

> Not all PCMCIA cards will work with TRDI products. To get a quote for a PCMCIA card supported by TRDI please contact TRDI Field Service or Sales (see How to Contact Teledyne RD Instruments).

Replacing the End Cap Connector

This section explains how to replace the 7-pin end-cap connector on a Workhorse or external battery.

> Some older WorkHorse end-caps may have the connector brass lock nut glued into place. If this is the case for your end-cap assembly, TRDI recommends that you purchase a new end cap assembly.

Equipment Provided

The WorkHorse End-Cap Tools Kit (P/N 757K6122-00) includes the following:

- Socket, lock nut removal
- Extracting wrench
- Plug, dummy, modified

The End Cap Replacement Kit 757K6125-00 (6000 meter systems) and 757K6149-00 (WorkHorse External Battery case) includes the following:

- 7-pin end-cap connector with cable and 2-014 O-ring
- Isolation bushing and 2-017 O-ring (metal end-caps only)
- Connector, header, 8-pin Molex or 2-pin as needed
- Fuses and fuse holders, wire, shrink tube (External Battery kit only)
- Nut, brass
- End-cap O-ring(s)
- Desiccant
- Silicon lubricant, 4-pack
- Loctite® 242
- Cord, lacing, black

Customer Supplied Additional Equipment

- Soft pad (ESD Safe) to rest WorkHorse on while dissembling and reassembly
- Socket wrench handle
- Torque Wrench (35 Inch/pound / 4 N-M)
- Multi-Meter

Removing the End-Cap Connector

To remove the end-cap connector:

1. Remove the end-cap from the housing.
2. Insert the modified dummy plug into the connector.

Figure 33. Modified Dummy Plug

3. Place the Extracting Wrench over the connector and dummy plug. The wrench will fit into the End Cap slot.

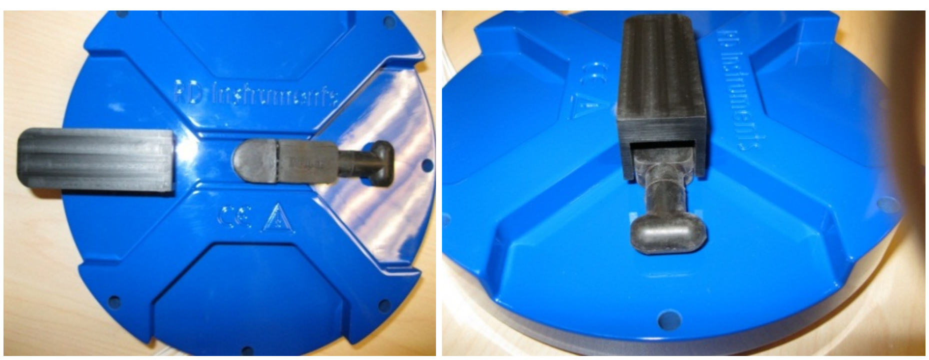


Figure 34. Extracting Wrench

4. Flip the end-cap assembly over and insert the socket onto the lock nut. Slide the cable wires into the socket's clearance slot.

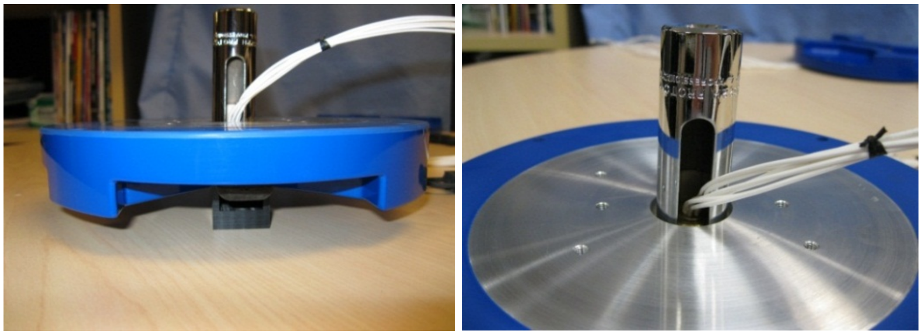


Figure 35. Lock Nut Removal Socket

5. Attach a ratchet wrench to the socket and remove the lock nut.

Figure 36. Removing the Connector

6. Remove the Molex 8-pin header connector by cutting the wires approximately 3-inches from the connector. Remove the connector from the end-cap.

> USE CAUTION – do not score or scratch the O-ring seal bore.

7. Remove all the tools and clean the end-cap thoroughly with Flux-Off® cleaner (or similar product). The O-ring pocket must be free of dirt, burrs and divots.

> Replace the end cap if any burrs or divots are found. These could provide a leakage path into the ADCP housing.

Installing the New End-Cap Connector

To install the new connector:

1. Clean the connector threads with Flux-Off® cleaner (or similar product).
2. Apply a **light** coat of silicon lubricant onto the O-rings (P/N 2-014 and 2-017).

> Do not over lube the O-rings.

3. Systems with a metal end-cap use an isolation bushing and 2-017 O-ring between the end-cap and the 7-pin connector. Press the new bushing and O-ring onto the end-cap as shown in Figure 37.

> Carefully check metal end-caps for signs of corrosion such as white deposits. If corrosion caused part of the end-cap to be visibly damaged, do not redeploy your system. Send it back to TRDI for inspection.

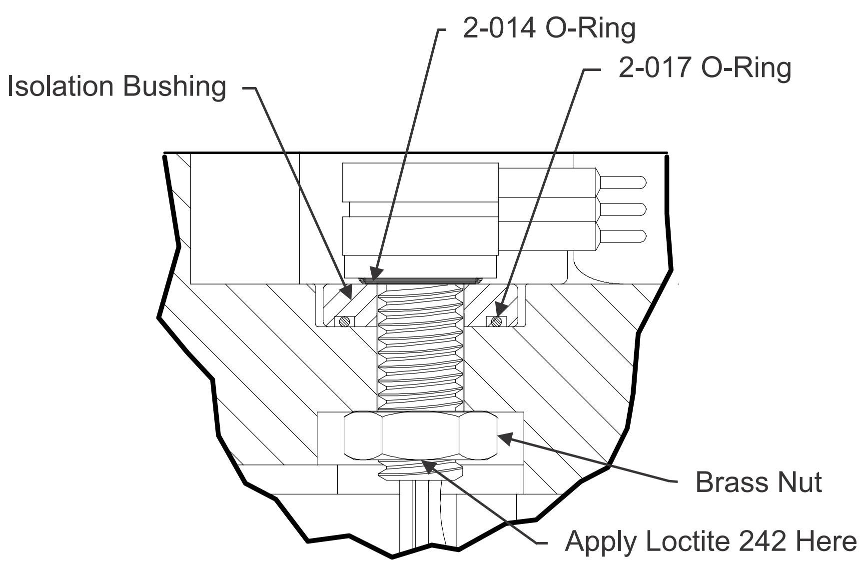


Figure 37. End-Cap Connector with Isolation Bushing

> The isolation bushing and 2-017 O-ring are required for metal end-caps only.

4. Install the O-ring onto the face seal groove located at the bottom of the threads on the connector.

> Do not scratch or mar the O-ring surface as you feed it over the threads of the connector.

5. Install the modified dummy plug. Pay attention to the pin orientation. **Do not bend the pins**.
6. Apply one drop of Loctite® 242 on the top starting threads of the connector.
7. Install the connector into the end cap by feeding the 7 wires and pins through the end-cap from the outside face (see Figure 33. Modified Dummy Plug).

> The connector pins should point away from beam 3.

8. Push the connector down so that it fully bottoms out in the O-ring pocket.

Do not score or scratch the bore or the O-ring pocket sealing face.

9. Feed the brass nut through the wires and pins and hand tighten onto the connector threads.
10. Place the Extracting Wrench over the connector and dummy plug. The wrench will fit into the End Cap slot between the 2 rails (see Figure 34. Extracting Wrench).
11. Flip the End-Cap assembly over and insert the slotted socket onto the lock nut. Fit the cable wires into the socket's clearance slot (see Figure 35. Lock Nut Removal Socket).
12. Attach a torque ratchet wrench to the socket and tighten the nut to 35 in/lbs., (4 NM). **Make sure that the connector is aligned straight and is parallel to the rails**.
13. Remove the assembly tools and the dummy plug.
14. Follow the wiring schematic in order to assemble the Molex 8-pin header connector or external battery case wiring (see Wiring Diagrams). Insert the pins into the connector. As the pin is pushed into the connector, the tabs on the pin will lock it into place.

Use the old cut-off Molex connector as a reference in addition to the schematic diagram when installing the new Molex connector. Each wire should have a corresponding J1 pin number tag.

15. After all the pins for the connector are installed, use a multi-meter to confirm that the connector has been wired properly by performing an end-to-end continuity check.
16. Use the black lacing cord to bind the connector wires together. The lacing is applied by wrapping it around the wire bundle approximately four times and then tying it securely with a square knot. Each wrap on the wire bundle should be spaced approximately 3-inches apart. This will prevent the wires from "bird caging" out and getting caught between the end-cap and pressure case O-ring.
17. For the WorkHorse External Battery Case, cut the wires on pins 1, 2, 4, 5, and 6 to 6mm long. Shrink wrap the bare ends of the wires. Place shrink wrap around the splices on pins 3 and 7 (see Figure 39. WorkHorse External Battery Case Wiring).

Wiring Diagrams

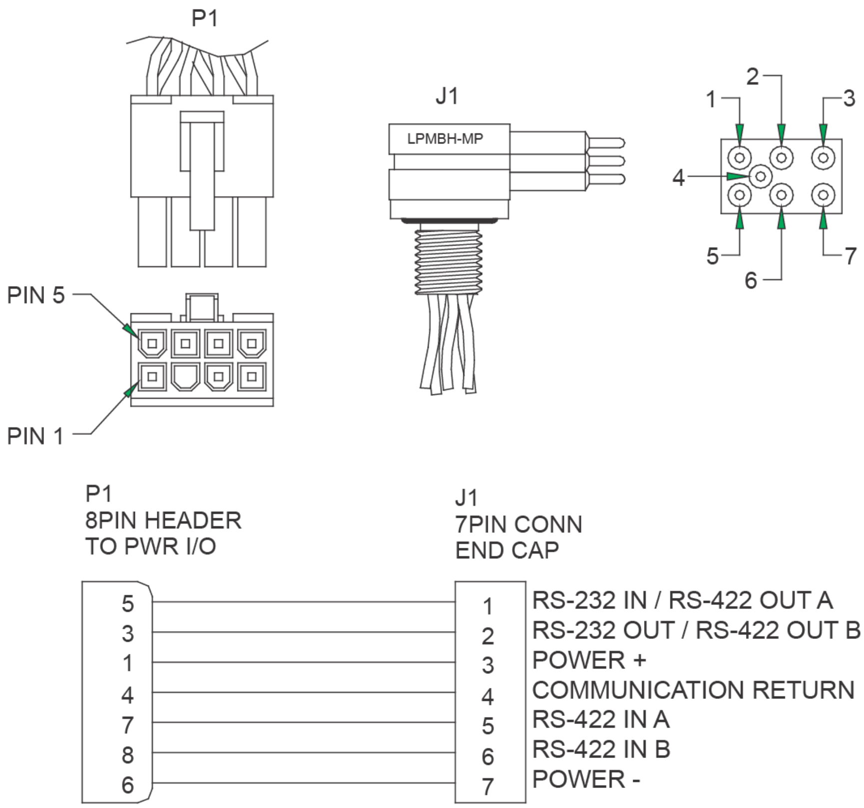


Figure 38. End-Cap Connector Wiring

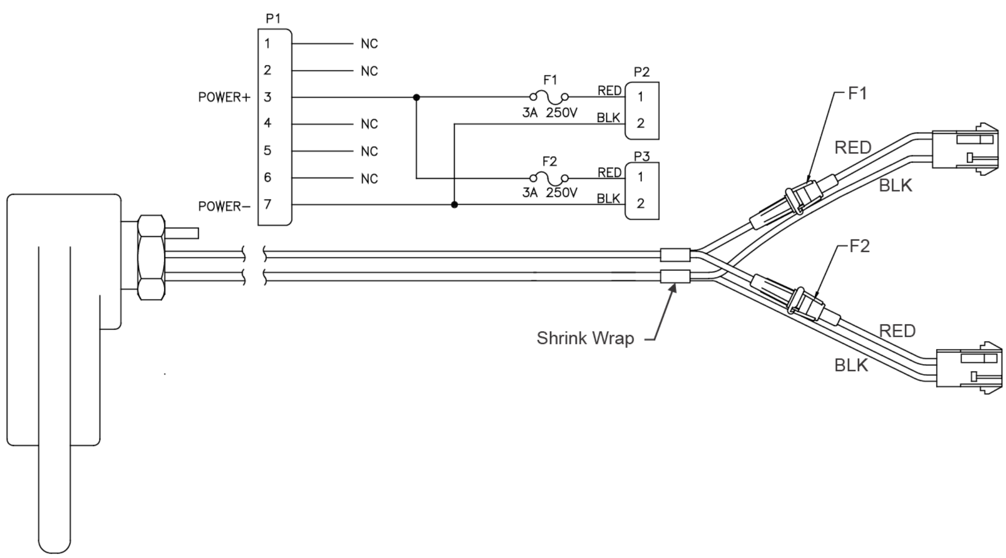


Figure 39. WorkHorse External Battery Case Wiring

Cut the wires on pins 1, 2, 4, 5, and 6 to 6mm long. Shrink wrap the bare ends of the wires. Place shrink wrap around the splices on pins 3 and 7.

Replacing the CPU Lithium Battery

This section explains how to replace the rechargeable lithium coin-cell battery in a Navigator system. The battery is located on the CPU board just below the PIO board transmit capacitors. The battery will recharge itself as soon as power is applied to the ADCP. Over time, the battery loses the ability to recharge and the voltage capacity drops. Therefore, **TRDI recommends replacing the battery every five years**.

The battery keeps the Real-Time Clock (RTC) running in case power is removed temporarily. The RTC drifts independently from the battery voltage by approximately 12 minutes/year. Clock drift does NOT indicate problems with the battery.

Equipment Required

- ESD safe work space
- Soft pad (ESD Safe) to rest WorkHorse on while dissembling and reassembly
- Anti-static ground strap
- Hex wrenches
- O-rings and desiccant for ADCP
- Soldering iron
- Digital multi-meter
- Lithium battery VL2330

To check for a failing lithium battery:

1. Charge the lithium battery by powering the system using external power and use *TRDI Toolz* to send the PC2 command to prevent the ADCP from sleeping. Let the system run for three hours.
2. Send the TS command and set the clock.
3. Remove all power to the system and wait at least 6 hours (two days is recommended). If you don't want to wait several days, open the housing. On the PIO board short TP10 (GND) to TP11 (VDD2) for 10 seconds using a jumper wire. Remove the jumper.
4. Power up the system and send the TS? command to verify the system time. If the time has reset to January 1, 2000 or is significantly incorrect, then you should verify the lithium battery voltage.

Testing the Lithium Battery Voltage

To verify that the lithium battery voltage:

1. Charge the battery by powering the system using external power and send the PC2 command to prevent the ADCP from sleeping. Let the system run for three hours.
2. Remove all power from the ADCP. Remove the housing assembly.

   Wait a few minutes after turning the power off before removing the electronics stack. This allows the transmit capacitors on the PIO board time to discharge.

3. Attach an earth-grounded wrist strap.

   Before handling any of the WorkHorse boards, you must be sure that you always wear an earth-grounding static protection strap. The electronics in the WorkHorse are very sensitive to electro-static discharge (ESD). ESD can cause damage that will not be seen immediately and will result in early failure of electronic components.

4. Remove the CPU board from the main electronic stack (see Installing the Spare Boards Kit).
5. Measure the voltage on the CPU board between TP17 (BAT+) and the small pin on the battery located on the back side of the CPU board (GND) (see Figure 40).

6. The voltage should hold stable at approximately 2 to 3 VDC for several hours at least, but for best results it should hold at 3 VDC for several days.
7. If the voltage is not holding for more than a week, then the battery may be defective. Before continuing, review your options:
   - Replace the Lithium battery yourself.
   - If you are uncomfortable with replacing the battery, please contact TRDI Customer Service Administration to schedule a replacement of the battery or request a Return Merchandise Authorization (RMA).

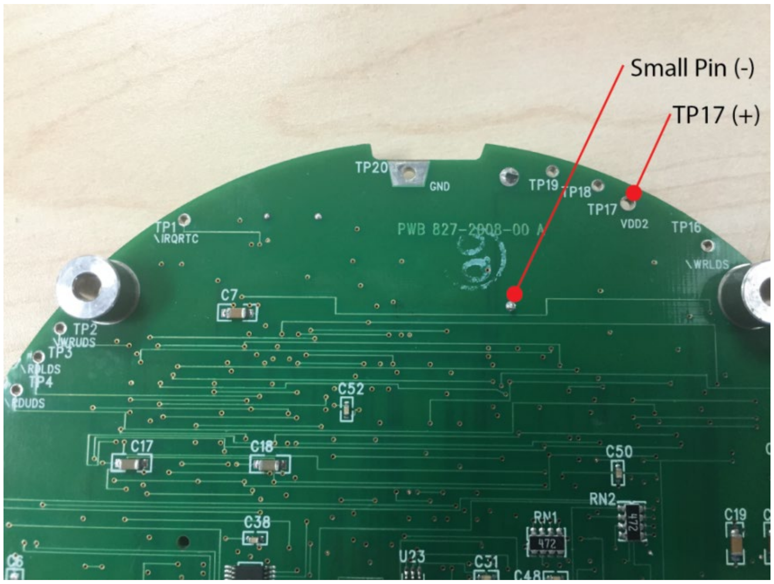


Figure 40. Lithium Battery Test Points on the CPU Board

Replacing the Lithium Battery

To replace the battery:

1. While wearing an earth-grounded wrist strap, locate the lithium battery B1 (on the top side of the CPU board).
2. De-solder the two associated pins for B1 which are located on the underside of the CPU board.
3. Install the new battery assembly (VL2330). Please note the battery pins; the battery can only be installed one way.

Figure 41. Lithium Battery

4. Verify the voltage holds stable at approximately 3 VDC (see Testing the Lithium Battery Voltage, step 2).
5. Replace the housing assembly. Make sure to use new O-rings and desiccant.

Installing the Spare Board Kit

This kit has been set up 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 Teledyne RD Instruments Customer Service Department so that you can return them for repair (see Contacting TRDI).

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.

TRDI assumes 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.

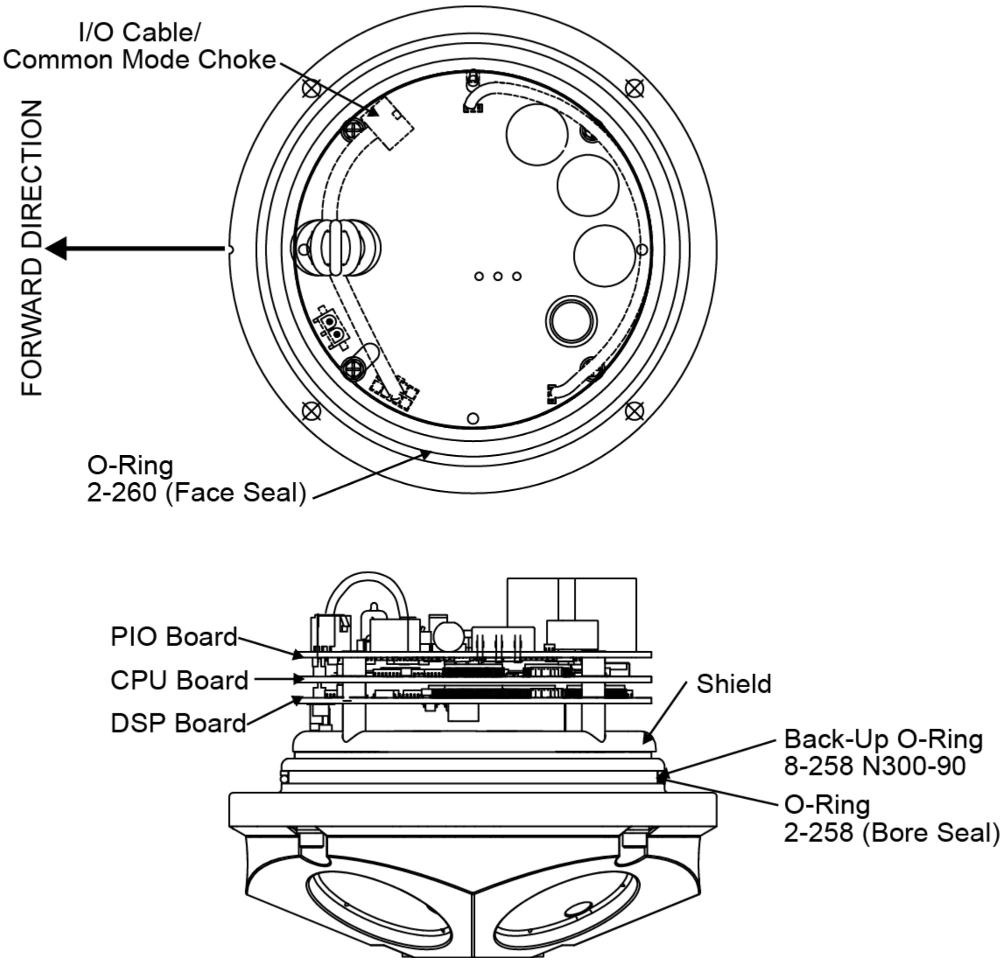


Figure 42. Navigator Board Locations

Remove the Original Set of Boards

To remove the boards:

1. Remove the Transducer assembly from the pressure case. Use Navigator Disassembly for instructions.
2. 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.
3. Note the orientation of the transmit cable connector as it is plugged into the PIO board and to the Receiver board (see Figure 43).

   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.

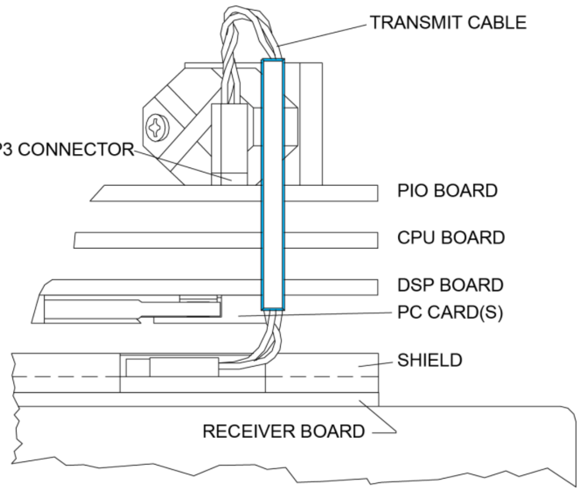


Figure 43. Transmit Cable

4. 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 44). 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, than 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.

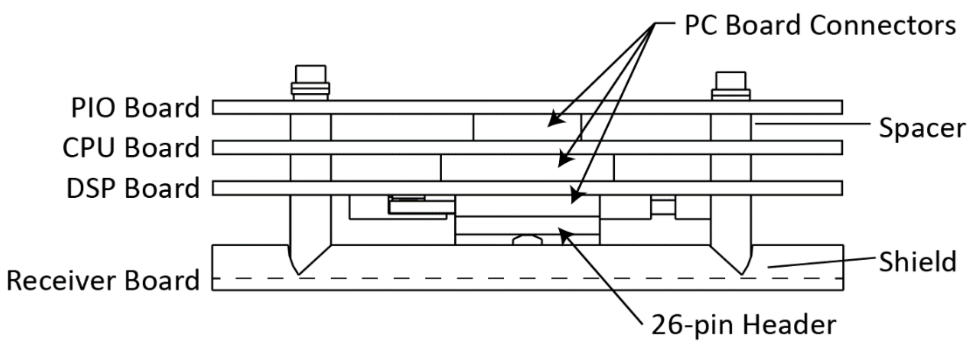


Figure 44. PC Board Connectors

5. 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.
6. Set the original board set to the side for now.

Installing the Spare Board Kit

To install the new boards:

1. With your earth-ground static protection strap on, remove the Spare Board Kit from the anti-static bag.
2. 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 45).

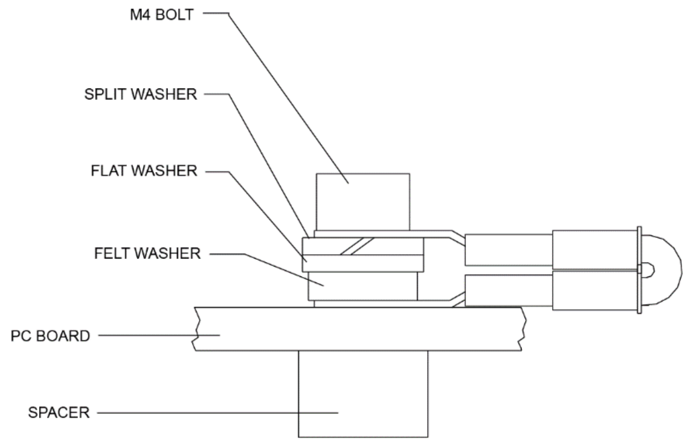


Figure 45. Ground Jumper

3. 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.
4. Install all PCMCIA cards removed in Remove the Original Set of Boards 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.
5. 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 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 *TRDI Toolz* 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
>
```

6. Insert the four new bolts and tighten to 4 Newton-meters.
7. Install the housing (see Navigator Re-assembly).

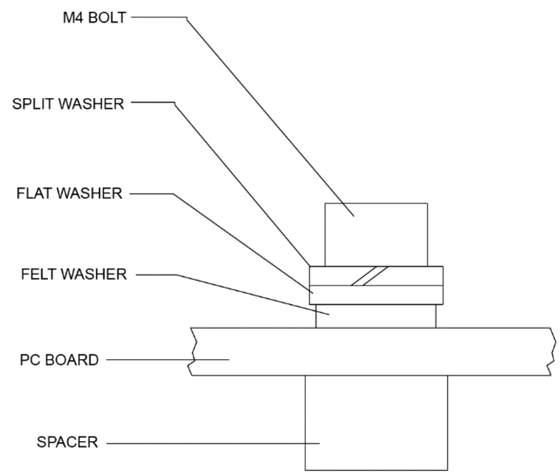


Figure 46. Mounting Hardware

Installing the Beam Cosine Matrix

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

To install the Beam Cosine Matrix:

1. Connect your Navigator DVL as you would normally and apply power.
2. Start *TRDI Toolz* and confirm that the Navigator DVL is communicating normally and what communications port you are using (COM 1 or COM 2).
3. Place the Beam Cosine Matrix Disk into your computer's disk drive.
4. 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.

Testing the System After Board Replacement

To test the systems after replacing the boards:

1. Install the Transducer in the Pressure Case.
2. Connect the cable and power as you normally do and test as DVL as shown in Testing the Navigator. All PA tests should pass when run in water and the PC tests should pass out of water.
3. ***Perform a field calibration of your compass*****.** Use Compass Calibration 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 (see How to Contact Teledyne RD Instruments).

Chapter 5

TESTING THE NAVIGATOR

In this chapter, you will learn:

- Testing the Navigator with *TRDI Toolz*
- Interpreting the Test Results
- Running the Sea Acceptance Tests

This chapter explains how to test the Navigator using the *TRDI Toolz* 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.

Testing the Navigator with *TRDI Toolz*

To test the DVL.

1. Interconnect and apply power to the system as described in Set up the Navigator.
2. Start the *TRDI Toolz* program (for help on using *TRDI Toolz*, see the help file).
3. Click the **Log** icon ( ) to save the test results to a file.
4. Click the **Break** icon ( ) and send the following commands: PS0, PS3, PA, PC2, PC1. The results of the tests will be displayed and saved to the log file selected in step 3.
5. Click the **Log** icon ( ) to end the log file.

Interpreting the Test Results

This section shows an example of the test result printout after running the test commands.

The built-in tests require you to immerse the transducer faces in non-moving 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).

Display System Parameters

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

```
>ps0
       Frequency:  614400 HZ
   Configuration:  4 BEAM, JANUS
     Match Layer:  10
      Beam Angle:  30 DEGREES
    Beam Pattern:  CONVEX
     Orientation:  DOWN
       Sensor(s):  HEADING  TILT 1  TILT 2  DEPTH  TEMPERATURE  PRESSURE
Pressure Sens Coefficients: (c3,c2,c1,offset) 0.00,0.00,0.08,0.00

Temp Sens Offset:  -0.15 degrees C

    CPU Firmware:  9.23 [0]
   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:
   5C  00 00 05 88 D6 9E  09 DSP727-2001-03H
   AE  00 00 05 89 25 01  09 CPU727-2000-00M
   B8  00 00 05 89 0F 5D  09 REC727-1000-03E
   95  00 00 05 89 31 87  09 PIO727-3000-00G
```

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.

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.

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...............................DETECTED
    Card Detect............................PASS
    Communication..........................PASS
    DOS Structure..........................PASS
    Sector Test (short)....................PASS
  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
  Wide Bandwidth...........................PASS
  Narrow Bandwidth.........................PASS
  RSSI Filter..............................PASS
  Transmit.................................PASS
SENSOR TESTS:
  H/W Operation............................PASS
>
```

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
```

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.

The PC1 test is designed to measure the relative noise in the environment and then have you apply more noise by rubbing the ceramics with your hand. Sometimes your hand does not generate enough noise for the system to detect. This could be due to the environment you are in or for other reasons. A simple, safe, and easy to find material that works very well as a replacement to your hand is packaging material (a.k.a. bubble wrap). Using this instead of your hand will very likely provide enough relative frictional difference for the system to pass.

```
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 ADCP 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
```

This test must be performed with the DVL out of water and preferably dry.

If the PC1 test fails, your system may still be okay. In this case deploy the DVL into a bucket or container of water (preferably at least 0.5 meters deep). Record some data using *TRDI Toolz* and the log file ( ), or record data straight to the recorder card if your DVL has one. Then look at the data using the *WinADCP* program and make sure that the echo amplitude counts in the 1st depth cell for all beams is between 128 and 192. If they are not, contact Field Service for further troubleshooting tips.

Running the Sea Acceptance Tests

This procedure is intended to test the Navigator at sea. This procedure assumes that the *TRDI Toolz* 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 *TRDI Toolz* 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)).

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 Set Up

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.

Table14: 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)

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 15: Navigator Altitude (Uncertainty±1%)

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

Chapter 6

TROUBLESHOOTING

In this chapter, you will learn:

- Troubleshooting a Communication Failure
- Troubleshooting a Built-In Test Failure
- Troubleshooting a Beam Failure
- Troubleshooting a Sensor Failure
- Navigator Cables Wiring Diagrams
- System Overview

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.

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 16: 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 TRDI (see How to Contact Teledyne RD Instruments for contact information) to obtain the correct part number for your specific system configuration. Please provide the serial number of the DVL when contacting TRDI about a replacement assembly. Please provide the cable length if you want to replace the I/O Cable.

Equipment Required

Special test equipment is not needed for trouble shooting and fault isolation. The required equipment is listed in Table 17. Any equipment satisfying the critical specification listed may be used.

Table 17: 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.

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

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 *TRDI Toolz* 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.

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 16). Before troubleshooting, review the procedures, figures, and tables in this guide. Also, read the System Overview to understand how the Navigator processes data.

Under all circumstances, follow the safety rules listed in the Troubleshooting Safety.

Troubleshooting Safety

Follow all safety rules while troubleshooting.

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

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.

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.

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.

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

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.

Do not attempt to open or service the power supply.

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.

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

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.

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

If you are using a high baud rate and/or a long I/O cable (greater than 50 meters) connected to a DVL, RS-232 may not work. Switch to RS-422 and try to wake up 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.

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 for symptoms of garbled wakeup messages.

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).

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.

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) 1996-2010
All Rights Reserved.
>
```

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.

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:

1. Connect the Navigator to a computer according to Set up the Navigator. Check that all cable connections are tight.
2. Is the AC power adapter working? Is the input voltage between 100 to 240 VAC? Is the output level 48 VDC?
3. 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.
4. Is the computer hooked up properly? Does it have power?
5. Make sure that your computer and the *TRDI Toolz* program are set up to use the communication port the I/O cable is connected to on the computer.

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).

- 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 for details.
- 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 (see DVL Checks). This can happen if you abort while downloading new firmware. Try downloading the firmware again.

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). 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.

Check the I/O Cable

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

1. Disconnect both ends of the cable and measure the continuity using a DMM (see Navigator Cables for the wiring diagram). Correct any problems found.
2. Reconnect the I/O cable to host computer.
3. Load *TRDI Toolz* on your computer. Select the proper communications port (see the RDI Tools User's Guide for help on using *TRDI Toolz*).
4. 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). 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.
5. 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.
6. 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.

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

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

To cold start the DVL:

1. Remove the housing to gain access to the PC boards.
2. Remove *all* power to the DVL.

> 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.

3. Short TP10 to TP11 on the PIO board for 10 seconds.
4. Remove the jumper.
5. 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 for fuse replacement procedures).

> 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.

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

> The Spare Boards kit is not included with the system. You can order the kit by contacting TRDI Customer Service department (see How to Contact Teledyne RD Instruments).

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 18: 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 Narrow Bandwidth RSSI Filter	Not in water External interference DSP or Receiver board failed
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

Troubleshooting a Beam Failure

The PC1 test is designed to measure the relative noise in the environment and then have you apply more noise by rubbing the ceramics with your hand. Sometimes your hand does not generate enough noise for the system to detect. This could be due to the environment you are in or for other reasons. A simple, safe, and easy to find material that works very well as a replacement to your hand is packaging material (a.k.a. bubble wrap). Using this instead of your hand will very likely provide enough relative frictional difference for the system to pass.

If the PC1 test fails, your system may still be okay. In this case deploy the DVL into a bucket or container of water (preferably at least 0.5 meters deep). Record some data using *TRDI Toolz* and the log file (icon), or record data straight to the recorder card if your DVL has one. Then look at the data using the *WinADCP* program and make sure that the echo amplitude counts in the 1st depth cell for all beams is between 128 and 192. If they are not, contact Field Service for further troubleshooting tips.

If the beam continuity test still 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
```

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
>
```

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 How to Contact Teledyne RD Instruments).

Fault Log

To determine why a sensor failed, view the fault log. To view the fault log, start *TRDI Toolz*. Press the **Break** icon ( ) to wake up 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.
```

Troubleshooting Data Problems

This list contains the different tasks that should be performed on the site where you experience data quality issue(s):

Identify the unit:

Prepare a separate log file (If using *TRDI Toolz*, press icon) or add at the beginning of your logged deployment data the returns from the following commands:

```
+++ (if using TRDI Toolz you can either send $B, click the Break button, or press <End> on the
keyboard)
PS0
PS3
PT200 (ensure the transducer beams are fully submerged in water prior to performing this test)
```

The returns from these commands will give us the unit Firmware version, the system operating frequency, beam matrix information and verify that the electronic is working as expected.

Run built-in tests:

If something FAILED in above PT200 test, repeat this test several times rotating the unit by 90 degrees each test. By doing so, it may be determined that the failure is directional. Please be sure to log the results by pressing icon if using *TRDI Toolz* to communicate with the system. If other magnetic or acoustic devices or high current system are in the vicinity of the unit (if possible), please power down the equipment and or remove the equipment (at least 3m away) during diagnostic testing, re-run the PT200 and log the data. Modify the log file by adding a note as of what has been done prior to a PT200 test such as: ***"Turning 300KHz Sonar off"*** for instance.

Always run PT200 test with unit transducer beams submerged in water. A bucket of water is sufficient but if possible run at least one PT200 on deployment site.

Provide unit setup:

Provide a text file with the commands sent to the unit during deployment – name the file as shown:

Script_File_[Vehicle_or Deployment_Name_and_Date&Time_Goes_Here].txt

If you do not send commands and use an unknown user default setting, query the following groups of commands:

```
>A?
>B?
>C?
>E?
>T?
>W?
```

For example, the bottom track group of commands for instance:

```
>B?
BA = 030 -------------- Evaluation Amplitude Min (1-255)
BB = 0320 ------------- 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 = 020 -------------- Gain Switch Depth (0-999 meters)
BK = 0 ---------------- Layer Mode (0-Off, 1-On, 2-Lost, 3-No BT)
BL = 160,0320,0480 ---- 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 = 02500 ------------ Maximum Depth (10-65535 dm)
BZ = 004 -------------- Coherent Ambiguity Velocity (cm/s radial)
>
```

Describe deployment and environment:

Provide a description of the environment where you are deploying – Specially emphasize on water and bottom description (for instance: grassy bottom, highly concentrated in sediment waters, etc.). Additionally, provide a description of the intended deployment; Specifically emphasize on speed commands, range expected, standard deviation expected, and goal of the mission.

Provide raw data & describe issue:

Recover the raw data from your instrument preferably in PD0 output format and send the complete deployment data together with a description of the issue that you are experiencing and if possible some screenshots or ensemble numbers to locate region(s) showing the unexpected data behavior. If it is not possible to provide PD0 data please identify the data format in which data was collected.

Provide additional necessary data:

If the data you recorded does not match alternate instrumentation providing the same data in the same reference frame, please provide the other device(s) data in a text file or a Matlab file (preferably in an ASCII format). If none of the above are feasible, screenshots of data plots could be provided in place of the above. Attach a description of the data and of the instrument from which it was recorded.

Record engineer data:

Re-deploy in the closest conditions and location from where the previous deployment occurred. However, prior to deployment add the following commands to your Script File or set-up commands. Ensure the commands are added prior to the CK (if used) or prior to CS:

```
PD0
&n0000 0000 0000 0100
```

Always deploy at constant speed or at least if constant speed cannot be sustained during the full deployment, try to maintain regular speed for as much time as possible. The more the speed is constant the more feasible it will be to compute and compare standard deviations with respect to vehicle's altitude and/or speed.

Additionally, deploy with the following commands added prior to CK or CS if no CK:

```
CR1
WP1(if water profile feature installed)
BP1(if bottom track feature installed)
EU2(if REMUS unit)
EX00111
BK0
TE00000000
TP000000
PD0
&n0000000000000100
```

As previously mentioned in reference to PT200 testing, if other devices are in the vicinity of the unit and are suspected to be the origin of the data quality issue, if possible power the device down or remove it from the area (at least 3m) and re-deploy using either one of the above set-ups, preferably both as the first one conserves your setting while the second returns to a more standard configuration both recording engineer data.

Finally, recover and provide TRDI Field Service with the raw binary (PD0) data.

Describe System Installation:

Provide a description of your vehicle, and more specially a description of the system, ADCP and/or DVL, installation(coupling with the vehicle, material used for the mounting plate, beams behind a fairing, voltage sent to the unit, triggering scenario implemented, etc.).

Navigator Cables Wiring Diagrams

This section has information on Navigator cabling. Special user-requests may cause changes to the basic wiring system and may not be shown here. TRDI provides 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.

Where shown, the color code is for reference only; your cable may be different.

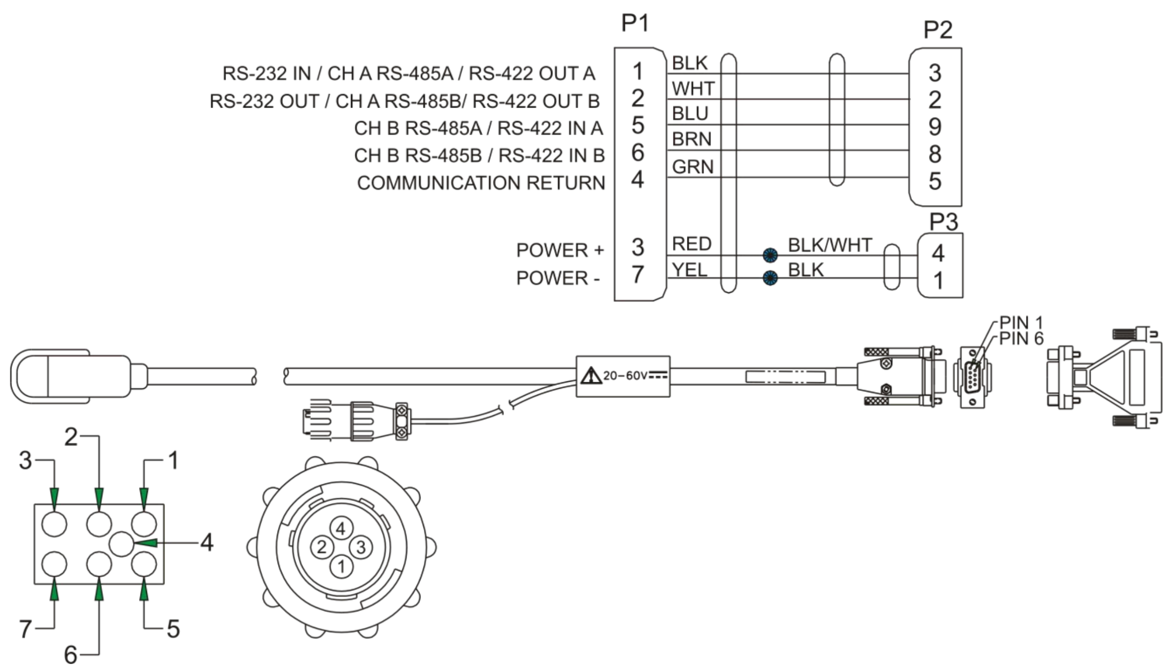


Figure 47. I/O Cable Wiring

Where shown, IN refers to signals going into the DVL and OUT refers to signals coming out of the DVL.

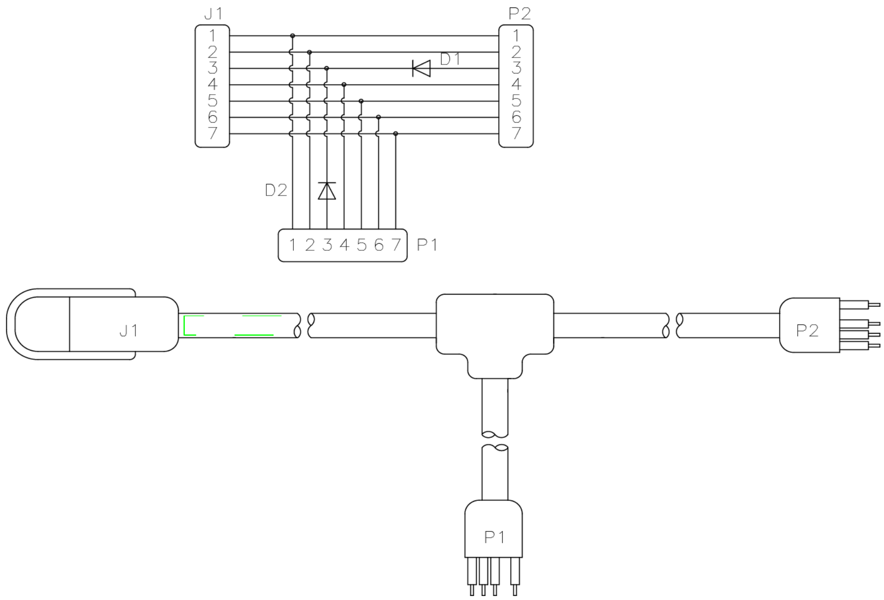


Figure 48. External Battery Pack "Y" Cable

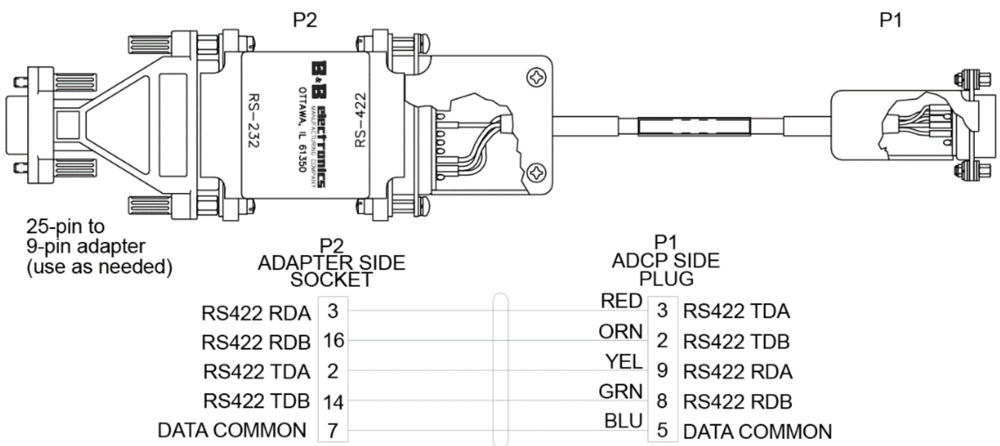


Figure 49. RS232-to-RS422 Converter Wiring (25-Pin to 9-Pin)

System Overview

This section presents a functional description of Navigator operation using block diagrams.

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, than 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 than 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.

Overview of Normal Navigator Operation

Refer to Figure 50 through Figure 52. The following events occur during a typical data collection cycle.

1. The user or a controlling software program sends data collection parameters to the Navigator. The user/program than 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 50 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).

2. 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.
3. The TRANSDUCERS receive echoes from the backscatter. The RECEIVER board amplifies and translates the echoes into a base-band frequency.
4. The CPU board processes the received echoes.
5. After echo reception, the Navigator injects a self-test signal into the RECEIVER board and processes the signal as normal data for test purposes.
6. The THERMISTOR measures water temperature at the transducer head and sends it to the CPU via the DSP Board.
7. 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.
8. 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.
9. At the end of the ensemble (sampling) interval, the CPU sends the collected data to the serial I/O connector or PCMCIA recorder.

Functional Description of Operation

The following paragraphs describe how the Navigator operates and interacts with its modules. Refer to Figure 51 through Figure 52 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 51 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 51). 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 housing 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.

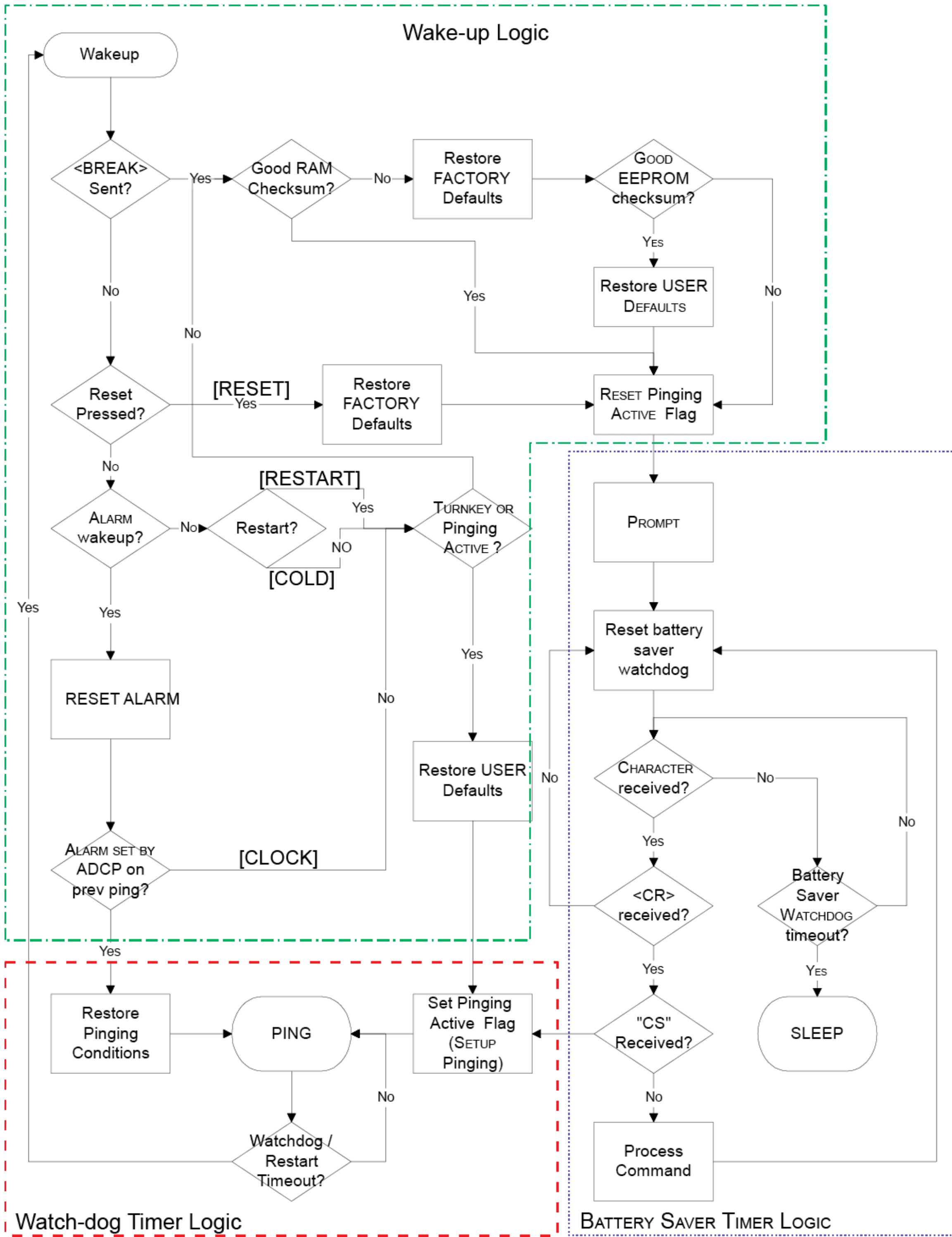


Figure 50. Navigator Wake-up and Timer Logic

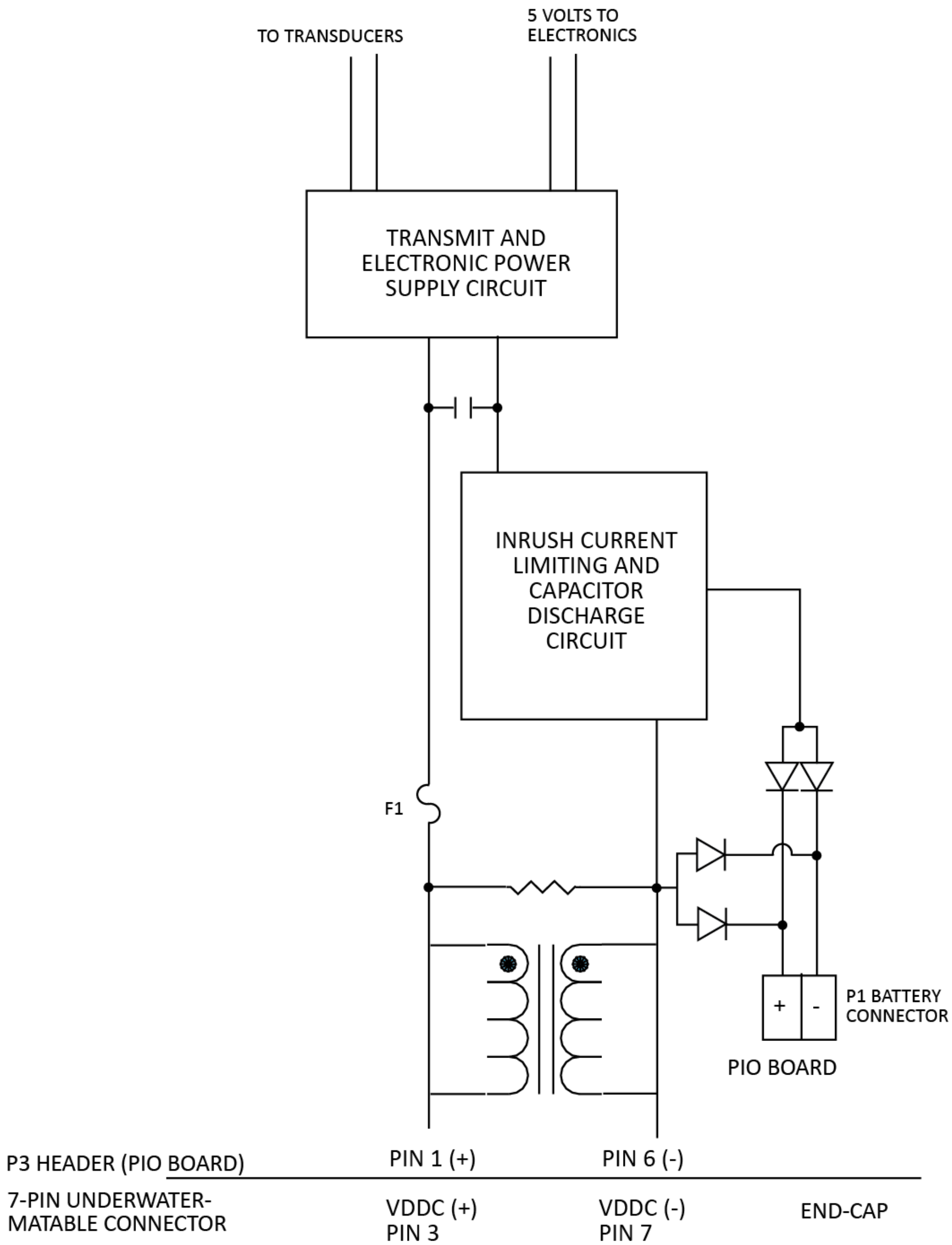


Figure 51. Navigator DC Power Path

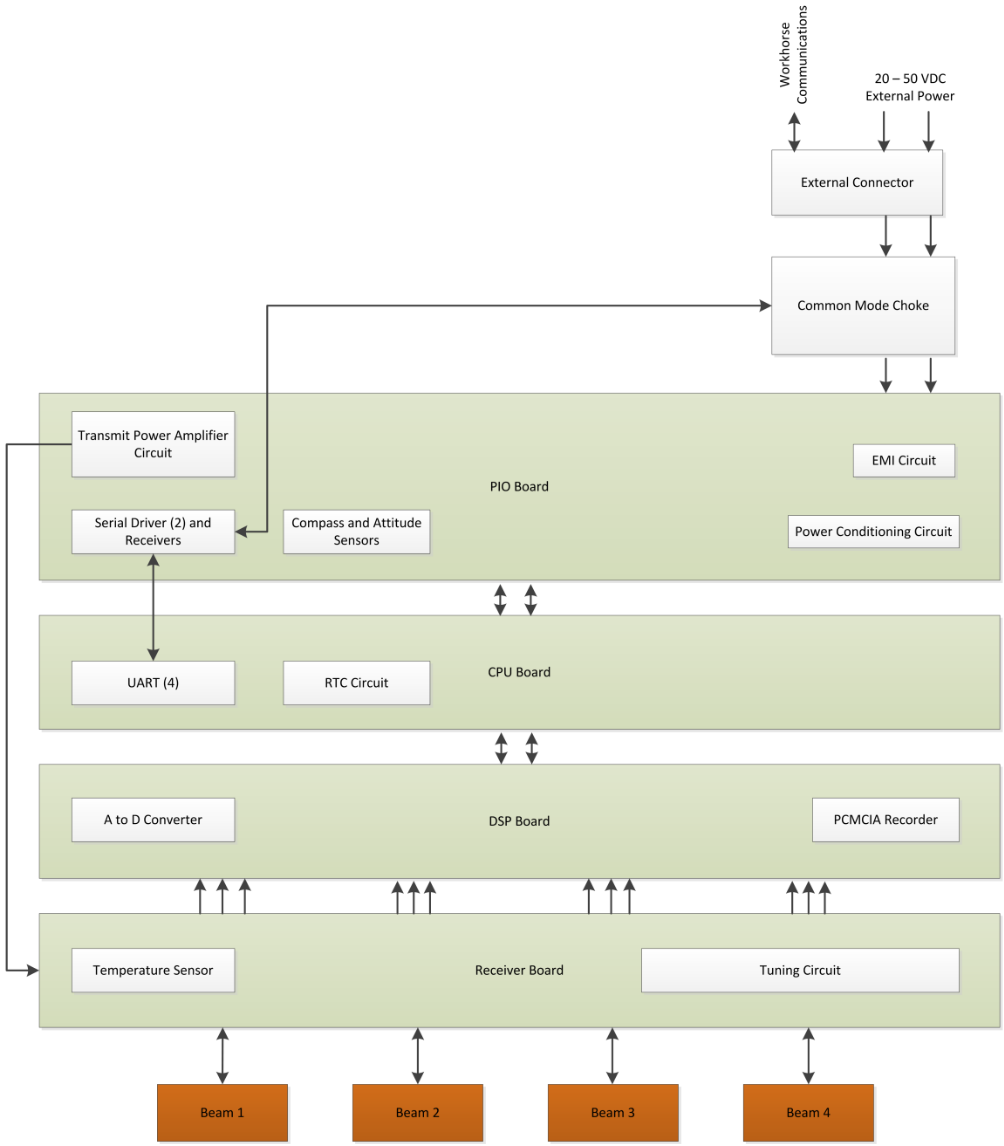


Figure 52. Navigator Block Diagram

NOTES

Chapter 7

RETURNING SYSTEMS TO TRDI FOR SERVICE

In this chapter, you will learn:

- How to pack and ship the DVL
- How to get a RMA number
- Where to send your DVL for repair

Shipping the DVL

This section explains how to ship the DVL.

Remove all customer-applied coatings or provide certification that the coating is nontoxic if you are shipping a DVL to TRDI for repair or upgrade. This certification must include the name of a contact person who is knowledgeable about the coating, the name, manufacturer of the coating and the appropriate telephone numbers. If you return the equipment without meeting these conditions, TRDI has 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 DVL through a Customs facility, be sure to place the unit so identifying labels are not covered and can be seen easily by the Customs Inspector. Failure to do so could delay transit time.

TRDI strongly recommends using the original shipping crate whenever transporting the DVL.

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

For repackaging with commercially available materials:

1. Use a strong shipping container made out of wood or plastic.
2. Install a layer of shock-absorbing static-shielding material, 70-mm to 100-mm thick, around all sides of the instrument to firmly cushion and prevent movement inside the container.
3. Seal the shipping container securely.
4. Mark the container FRAGILE to ensure careful handing.
5. In any correspondence, refer to the DVL by model and serial number.

Returning Systems to the TRDI Factory

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

Step 1 - Request a Return Material Authorization

To obtain a Return Material Authorization (RMA) number and shipping instructions for the return of your instrument, do one of the following:

- Contact Customer Service Administration at rdicsadmin@teledyne.com
- Call +1 (858) 842-2700

When requesting a RMA number, please give us the following information:

- What is being shipped (include the serial number)
- When you plan to send the shipment
- What issue(s) need to be corrected
- Name of the Field Service Engineer that knows about the issue
- When you need the instrument returned

TRDI's Customer Service will then respond with the RMA number for the shipment. Please include this number on all packages and correspondence.

Step 2 – Provide a MSDS as necessary

Please provide a Material Safety Data Sheet (MSDS) if the system/transducer is painted with antifouling paint.

Step 3 - Ship via air freight, prepaid

Urgent Shipments should be shipped direct to TRDI via overnight or priority air services. Do not send urgent airfreight as part of a consolidated shipment. If you ship consolidated, it will cost less, 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: Teledyne RD Instruments, Inc. (RMA Number)
14020 Stowe Drive
Poway, California 92064

Airport of Destination = San Diego
Notify Paxton, Shreve and Hayes

Phone: +1 (619) 232-8941
Fax: +1 (619) 232-8976

Step 4 - Urgent shipments

Send the following information by fax or telephone to TRDI.

Attention: Customer Service Administration

Fax: +1 (858) 842-2822

Phone: +1 (858) 842-2700

- 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

Returning Systems to TRDI Europe Factory

When shipping the system to TRDI Europe, the following instructions will help ensure the DVL arrives with the minimum possible delay. Any deviation from these instructions increases the potential for delay.

Step 1 - Request a Return Material Authorization

To obtain a Return Material Authorization (RMA) number and shipping instructions for the return of your instrument, do one of the following:

- Contact Customer Service Administration at rdiefs@teledyne.com
- Call +33(0) 492-110-930

When requesting a RMA number, please give us the following information:

- What is being shipped (include the serial number)
- When you plan to send the shipment
- What issue(s) need to be corrected
- Name of the Field Service Engineer that knows about the issue
- When you need the instrument returned

TRDI's Customer Service will then respond with the RMA number for the shipment. Please include this number on all packages and correspondence.

Step 2 – Provide a MSDS as necessary

Please provide a Material Safety Data Sheet (MSDS) if the system/transducer is painted with antifouling paint.

Step 3 - Ship Via Air Freight, Prepaid

Urgent Shipments should be shipped direct to TRDI via overnight or priority air services. Do not send urgent airfreight as part of a consolidated shipment. If you ship consolidated, it will cost less, 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.

Mark the package(s) as follows:

To: Teledyne RD Instruments, Inc. (RMA Number)
2A Les Nertieres
5 Avenue Hector Pintus
06610 La Gaude, France

Step 4 - Include Proper Customs Documentation

The Customs statement must be completed. It should be accurate 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 5 - 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

NOTES

Chapter 8

NAVIGATOR COMMANDS

In this chapter, you will learn:

- How to enter commands
- Data output processing
- Firmware and feature updates
- Command descriptions

This section defines the commands used by the Navigator. These commands (Table 19) 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 *before deploying your DVL*. Most Navigator settings use factory-set values (Table 20). 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 19 directly affect the range of the DVL, the standard deviation (accuracy) of the data, and battery usage.

> This section applies to Navigator firmware 9.23 or higher.
>
> 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 TRDI's web site often at www.rdinstrument.com.

Data Communication and Command Format

Enter commands with an Windows® compatible computer running TRDI's *TRDI Toolz*. The Navigator communicates with the computer through an RS-232 (or RS-422) serial interface. TRDI initially sets 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 *TRDI Toolz* by pressing the **Break** icon ( ). 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 9.23
RD Instruments (c) 1996-2013
All rights reserved.
>
```

> If you use a terminal/program other than *TRDI Toolz*, the BREAK length (up to down transition) must last at least 300 ms.

Entering Commands

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.

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.

All of Teledyne 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).

Updating the Firmware

Contact your local sales representative if you are interested in updating the firmware.

To update the firmware:

1. Set up the Navigator as shown in Set up the Navigator.
2. Start the program *WHNx.exe* (where *x* = the firmware version). Click **Setup**.
3. Click the **View README.TXT** button to view the Readme.txt file for details on what is new in this version of firmware.
4. Click **Next** and follow the on-screen prompts.
5. If you are not able to install the new version of firmware, contact Customer Service for assistance.
6. After successfully upgrading the firmware, use *TRDI Toolz* to test the DVL.

Installing 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.

> The upgrade disk is specific to the unit for which it was ordered. DO NOT attempt to install this feature for any other unit.
>
> 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).
>
> Contact your local sales representative if you are interested in upgrading your system.

> Shallow Water Bottom Track Mode 7 can only be installed on 1200kHz systems.

To install a feature upgrade:

1. Set up the Navigator as shown in Set up the Navigator.
2. Place the feature upgrade CD into the CD-ROM drive.
3. Use Windows Explorer® to open the CD drive folder.
4. Double-click on the *xxx*.exe, where *xxx* is the DVL's CPU serial number. The installation program will start (see Figure 53). The program is encoded with the DVL's serial number and the requested feature upgrade.

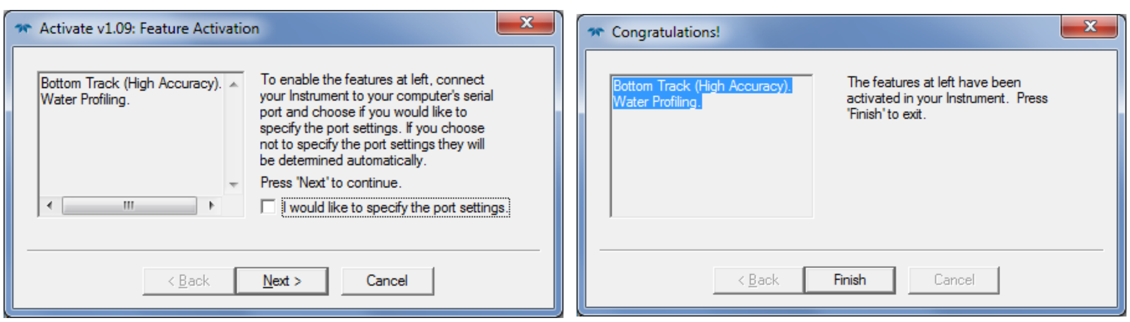


Figure 53. Installing Feature Upgrades

5. To select the port settings, select the **I would like to specify the port setting** box and click **Next**.
6. Select the **Serial Port** and **Baud Rate**.
7. Click **Next** to install the feature upgrade. Click **Finish** to exit the program.
8. Start *TRDI Toolz* and use the OL command (see OL - Features) to verify the feature upgrade has been installed.

Command Summary

Table 19 gives a summary of the Navigator input commands, their format, and a brief description of the parameters they control. Table 20 lists the factory default command settings.

This table shows all commands including optional shallow water Bottom Mode 7 and water profiling feature upgrades (highlighted in yellow). Some commands may not be available for your DVL.

Table 19: 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 Altitude (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 Altitude (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*nnn*	Periodic Output 1/10 sec. (0-Off, [10-600])
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)
EP±*nnnn*	Pitch (-60.00 to +60.00 degrees)
EQ*n*	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

Table 19: Navigator Input Command Summary

Command	Description
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
SA*xyz*	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))
TB*hh:mm:ss.ff*	Time per burst
TC*nnnn*	Ensemble per burst (0 to 65535)
TE*hh:mm:ss.ff*	Time per ensemble (hours:minutes:seconds.100th of seconds)
TF*yy/mm/dd, hh:mm:ss*	Time of first ping (year/month/day, hours:minutes:seconds)
TG*ccyy/mm/dd, hh:mm:ss*	Time of first ping (Y2k compatible) (century year/month/day, hours:minutes:seconds)
TP*mm:ss.ff*	Time between pings (minutes:seconds.100th of seconds)
TS*yy/mm/dd, hh:mm:ss*	Set real-time clock (year/month/day, hours:minutes:seconds)
TT*ccyy/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)
WI*n*	Clip data past bottom (0 = Off, 1 = On)
WJ*n*	Receiver gain select (0 = Low, 1 = High)
WL*sss,eee*	Water reference layer
WM*n*	Water Profiling mode (1, 5, 8)
WN*nnn*	Number of depth cells (1 to 128)
WP*nnnn*	Pings per ensemble (0 to 16384)
WQ*n*	Sample ambient sound (0 = Off, 1 = On)
WS*nnnn*	Depth cell size [min, max] 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 700 cm/s radial)
WW*nnn*	Mode 1 Pings before Mode 4 Re-acquire
WX*nnn*	Mode 4 Ambiguity Vel (cm/s radial)
WZ*nnn*	Mode 5 ambiguity velocity (5 to 80 cm/s)

Table 20: 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
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

Table 20: Navigator Factory Defaults

Command	300 kHz	600 kHz	1200 kHz
BZ	004	004	004
CA	000	000	000
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	EZ1111101	EZ1111101	EZ1111101
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	1000	1000	1000
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
WW	004	004	004
WX	999	999	999
WZ	010	010	010

The highlighted commands have frequency dependent defaults.

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 9.23
RD Instruments (c) 1996-2013
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 *TRDI Toolz*, pressing the **Break** icon ( ) sends a BREAK.

Example <BREAK>

```
[BREAK Wakeup A]

Navigator DVL Version 9.23
RD Instruments (c) 1996-2013
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 9.23
RD Instruments (c) 1996-2013
All Rights Reserved.
>
```

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>.

In order for the software breaks to work, the CL command must be set to CL0.

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 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
Shallow Bottom Mode                                             No

See your technical manual or contact TRDI for information on how to
install additional capability in your WorkHorse.

>
```

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.

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
```

Compass Command Descriptions

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.

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 second 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.

For details on compass alignment, see Compass Calibration

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 5° of rotation for a full 360° 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 calibration.
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.

If the pressure sensor is not installed, using the AZ command will generate the following error.

```
Err: No pressure sensor detected
```

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.

Available Bottom Track Commands

This section lists the available Bottom Track commands.

```
>b?
BA = 030 ----------------- Evaluation Amplitude Min (1-255)
BB = 0160 ---------------- 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 = 010 ----------------- Gain Switch Depth (0-999 meters)
BK = 0 ------------------- Layer Mode (0-Off, 1-On, 2-Lost, 3-No BT)
BL = 080,0160,0240 ------- 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 = 01250 --------------- Maximum Depth (10-65535 dm)
BZ = 004 ----------------- Coherent Ambiguity Velocity (cm/s radial)
```

Bottom Track Command Descriptions

BA – Evaluation Amplitude Minimum

Purpose	Sets the minimum value for valid bottom detection.
Format	BA*nnn*
Range	*nnn* = 0 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 Altitude

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.

If you are operating behind a fairing/hull, 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.

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 than 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.

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) and only three beams are good, than 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 Navigator transmits a fixed pulse based on a given bottom range. During each bottom track ping, the depth from the previous ping is used to set the search range for the next ping. The BF command forces the “previous” ping’s depth to the entered value, so that the search window is set up based on that entered range, which never changes. This is useful for applications with fixed range bottoms. The command reduces the amount of time the Navigator uses to search for the bottom if lost. If the bottom appears near the BF range, the Navigator will find it. However, if the bottom gets to be greater than approximately ((BF * 2) - 2 * XmtLength), than the Navigator will not find the bottom, because when the BF command is used, the search algorithm is disabled.

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.

This command is used for Bottom Track Mode 6 only. Read FSA-012 - Configuring Bottom Mode 6 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 0,30,000

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.

This command is used for Bottom Track Mode 6 only. Read FSA-012 - Configuring Bottom Mode 6 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 3,0,0000

Recommended Setting. The default setting for this command is recommended for most applications.

Description The command allows only Bottom Mode 6 to be set up 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 21: 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).
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 BL160,0320,0480 (300 kHz), BL080,0160,0240 (600 kHz), BL040,0060,0100 (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 54, B), the layer compresses in size until the minimum water-mass layer size is reached. When the boundary moves closer to the transducer (Figure 54, C), no water mass ping will be sent.

The water-mass layer is operational only if BP > zero and BK > zero.

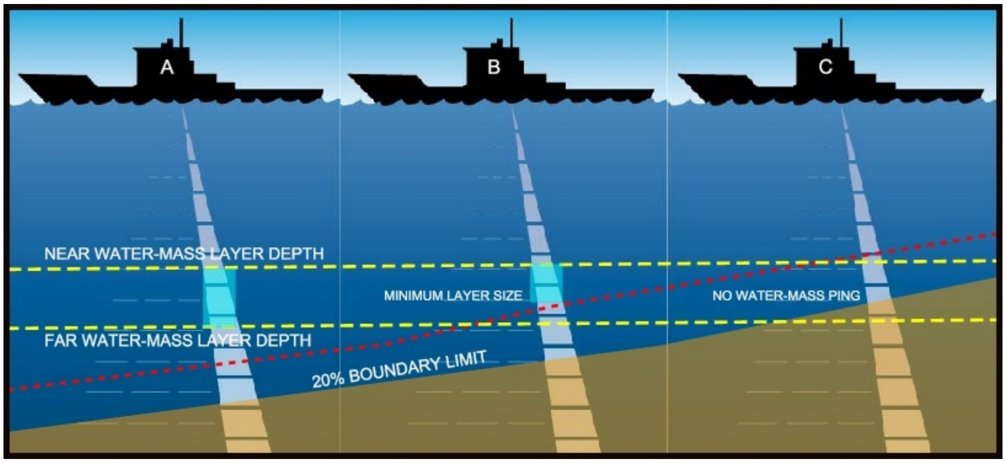


Figure 54. Water-Mass Layer Processing

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.

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 22: 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.

Bottom Track Mode 7

Bottom Mode 7 is a feature upgrade for 1200kHz Navigator DVLs only (see Feature Upgrades). 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 23). 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.

Table 23: BM7 Minimum Tracking Depths

Frequency	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: BN0,025

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, than the accumulated distance is set to zero. If *x* is one, than 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: BO025

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.

The DVL interleaves bottom-track pings with water-track pings (see TP – Time Between Pings) 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, than the depth would read 100 meters until you passed 104 meters. If you had BR2 set, than 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, than 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, than no velocity will be output for this case.

A count value of 255 is perfect correlation.

This command is only available if the Bottom Mode 7 feature upgrade is enabled (see Feature Upgrades).

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), than the DVL will perform five bottom pings, one water reference ping, five bottom pings, than one water reference ping.

The BK-command must be set to one (BK1) for this command to work.

BX – Maximum Tracking Depth

Purpose Limits the search range for bottom tracking.

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.

The BX command limits the search range for bottom tracking. If the DVL loses lock on the bottom, it goes into search mode, which iteratively searches increasing ranges until either the bottom is found or the maximum range is reached, and then the process starts over at the minimum range. The BX command will prevent the DVL from searching to ranges beyond the BX range value, and can result in shorter search cycles if the bottom is known to be within this range. Setting a BX range limit will not prevent the DVL from tracking the bottom to its maximum range capability as long as it maintains a lock on the bottom.

BZ – Coherent Ambiguity Velocity

Purpose Sets the Bottom-Track Mode 5 ambiguity velocity.

Format BZ*nnn*

Range *nnn* = 2 to 160 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.

Control System Commands

The Navigator DVL uses the following commands to control certain system parameters.

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 = 88008000 ------------ Clear Error Status Word
CZ ----------------------- Power Down Instrument
```

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 CA000

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).

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.

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 (see Changing the Baud Rate in the DVL).

Table 24: 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		

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).

The *VmDas* program sets the Navigator to a manual ensemble mode (CF01110) so that it controls when the ensemble occurs.

Table 25: 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.

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 – Sleep Between Pings

Purpose Determines whether the DVL will attempt to conserve power by sleeping between pings.

Format CL*n*

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.

> For CL0, if a command is sent after the break, the ADCP will not redeploy until a CS command is sent.

In order for software breaks to work, the CL-command must be set to CL0 (see Break).

When using the command file provided with VmDas with a DVL with firmware version 9.21 or higher, if *VmDas* times out between each ensemble, adding CL0 to the command file fixes the problem.

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 (approximately 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).

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 26: 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).

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.

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

Recommended Setting. The default setting for this command is recommended for most applications.

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 than send the CT1 and CK commands to save this configuration and then send a CS command to begin pinging. 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 at the ">" prompt. *If any valid command is sent at this time, cycling the power will **NOT** start the data collection process*; another CS command must be sent to start collecting data.

If no command is sent at the ">" prompt, cycling the power to the DVL will start it pinging again.

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.

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.

The CX command inhibits the ability of the Navigator to sleep and conserve power. Use CX1 only when power consumption is not an issue.

If CX1 is used, the CL command must be set to CL0 (see CL – Sleep Between Pings).

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 27: 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

ESW	Description
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.

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:

1) 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.

2) If the DVL is in the command mode when power is lost, when power is restored, it will wake up in the command mode. If a timeout occurs, the DVL will power down automatically.

The ESW is written to the ensemble (see Figure 59). 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).

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.

Environmental Commands

The Navigator uses the following commands to control the environmental and positional information that affects internal data processing.

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 = EZ1111101 ----------- Sensor Source (C;D;H;P;R;S;T)
```

Environmental 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 downward in place on a moving ship (see Figure 7, page 22). Beam 3 has been rotated 45 clockwise (+45) from the ship's centerline (0) to the starboard. 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.

> 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.

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.

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)
Default	EH00000

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
```

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* = -6000 to 6000 (-60.00 to +60.00 degrees)

Default EP+0000

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
```

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.

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* = -6000 to 6000 (-60.00 to +60.00 degrees)

Default ER+0000

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
```

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
```

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 28: 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, than 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, than 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)

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.

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.

See What coordinate system should I use and why.

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 29: 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.

When using EZ3xxxxxx, the data cannot be output through the serial port at 115200 baud. Although a string will be sent through the serial cable, this string is corrupted. Please use 57600 baud or lower should you need serial data output when using EZ3xxxxxx. If data is being sent to the recorder, then any baud rate can be used.

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.

Fault Log Commands

The Navigator uses the following commands to aid in troubleshooting and testing.

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
```

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.

Performance and Testing Commands

The Navigator uses the following commands for calibration and testing.

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
```

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.

Run the PA test in **non-moving** water as running these tests in air will give false failures.

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..............................NOT DETECTED
DSP TESTS:
  Timing RAM..............................PASS
  Demod  RAM..............................PASS
  Demod  REG..............................PASS
  FIFOs...................................PASS
SYSTEM TESTS:
  XILINX Interrupts... IRQ3  IRQ3  IRQ3 ...PASS
  Wide Bandwidth..........................PASS
  Narrow Bandwidth........................PASS
  RSSI Filter.............................PASS
  Transmit................................PASS
SENSOR TESTS:
  H/W Operation...........................PASS
>
```

The Wide Bandwidth and Narrow Bandwidth tests may fail if transducer is not in water. The 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. Sometimes your hand does not generate enough noise for the system to detect. This could be due to the environment you are in or for other reasons. A simple, safe, and easy to find material that works very well as a replacement to your hand is packaging material (a.k.a. bubble wrap). Using this instead of your hand will very likely provide enough relative frictional difference for the system to pass.

If it doesn't, the system still might be okay. In this case deploy the DVL into a bucket or container of water (preferably at least 0.5 meters deep) and record some data using *TRDI Toolz* and the log file (icon), or you can record data straight to the recorder card if your DVL has one. You can than look at the data in our

WinADCP program and make sure that the echo amplitude counts in the 1st depth cell for all beams is between 128 and 192. If they are not, contact Field Service for further troubleshooting tips.

```
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
```

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 = 0-6, 10, 11, 13, (see description)

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 30).

Table 30: 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.
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.
PD13	PD13 is a text output format similar to PD6 with the addition of information about range to bottom and raw pressure sensor data.

All of TRDI's software supports PD0 formatted data only.

The table above gives a brief overall description of the data format output. For details on the actual data output please see Introduction to Output Data Format.

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).

TEST=A,BCD,EFGHI-JKLMN,PQRS,TUVWXY,Z

Table 31: 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

Run the PF test in **non-moving** water as running these tests in air will give false failures.

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
       Frequency:  614400 HZ
   Configuration:  4 BEAM, JANUS
     Match Layer:  10
      Beam Angle:  30 DEGREES
    Beam Pattern:  CONVEX
     Orientation:  DOWN
       Sensor(s):  HEADING  TILT 1  TILT 2  DEPTH  TEMPERATURE  PRESSURE
Pressure Sens Coefficients: (c3,c2,c1,offset) 0.00,0.00,0.08,0.00

Temp Sens Offset:  -0.15 degrees C

    CPU Firmware:  9.23 [0]
   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:
   5C  00 00 05 88 D6 9E  09 DSP727-2001-03H
   AE  00 00 05 89 25 01  09 CPU727-2000-00M
   B8  00 00 05 89 0F 5D  09 REC727-1000-03E
   95  00 00 05 89 31 87  09 PIO727-3000-00G
```

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 32: 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) by the individual bit settings:

Table 33: 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).

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
```

Run the PT4 test in **non-moving** water as running these tests in air will give false failures.

PT4 failure description - You can determine failure results ($>0 see PT Test Results Error Codes) by the individual bit settings:

Table 34: 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.

Bit #	PT4 Failure Description
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).

The test failure example shown below is what you would see for a missing or improperly attached transmit cable (see Troubleshooting).

```
>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
```

Run the PT5 test in **non-moving** water as running these tests in air will give false failures.

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
```

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
```

Run the PT6 test in **non-moving** water as running these tests in air will give false failures.

Table 35: PT6 Receive Bandwidth Nominal Values

Bandwidth setting	WB command	150kHz	300 kHz	600 kHz	1200 kHz
Broad	0	45	120	200	480
Narrow	1	12	28	40	112

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
>
```

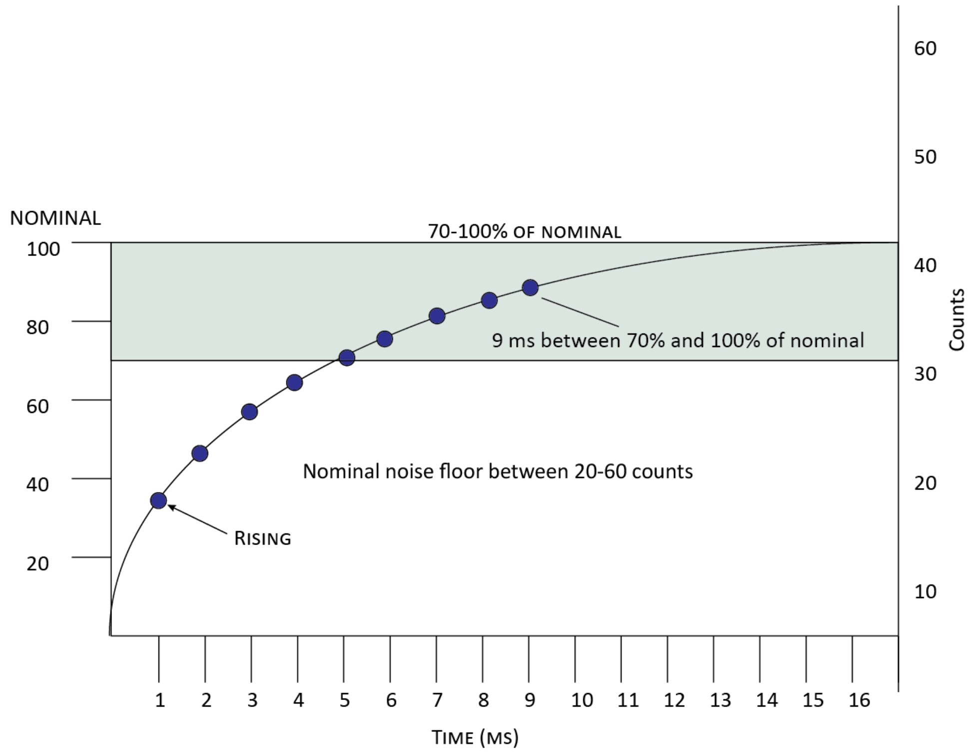


Figure 55. PT7 RSSI Bandwidth Test

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

Recorder Commands

The following paragraphs list all the Navigator recorder commands.

Navigator DVLs can use optional memory cards (see PC Card Recorder). The maximum memory for each slot is 2GB, with the total memory capacity not to exceed 4GB.

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  _RDI_ ---------------- Set Deployment Name
RR ----------------------- Recorder diRectory
RS ----------------------- Recorder Space used/free (Mb)
RY ----------------------- Upload Recorder Files to Host
R? ----------------------- Display Recorder Commands
```

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.

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.

Ping Synchronization Commands

The Teledyne RD Instruments Sleepy Sensor Synchronization (RDS3) protocol allows a Navigator to synchronize measurements with another Navigator or any other instrument that adheres to the RDS3 specification.

Available Ping Synchronization Commands

This section lists the available Ping Synchronization commands.

```
>s?
SA = 000 ----------------- Synch Before/After Ping/Ensemble Bottom/Water/Both
SB = 1 ------------------- Channel B Break Interrupts are ENABLED
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)
>
```

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 SA000

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 36: 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.

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.

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)

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.

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. A TRDI DVL, set up 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 37: Sleep Mode Parameters

Parameter	Description
SS0	Wait between pings (synchronization pulses) in a loop.
SS1	Wait between pings (synchronization pulses) in a sleep state.

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 its 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 its own should communications with the master DVL fail. Setting ST = 0 tells the slave to wait indefinitely.

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).

This command has no effect unless SM = 1 or 3

Timing Commands

These commands let you set the timing of various profiling functions.

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 = 10/04/28,04:05:49 --- Time Set (yr/mon/day,hour:min:sec)
TT = 2010/04/28,04:05:49 - Time Set (CCYY/MM/DD,hh:mm:ss)
```

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 99 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.

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, 2013 at 1:37:15 pm, enter TF13/11/23, 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.

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, 2013 at 1:37:15 pm, you would enter TG 2013/11/23, 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.

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.

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 *TRDI Toolz*, *PlanADCP*, *VmDas*, or *WinRiver*.

Example — TS13/06/17, 13:15:00 sets the real-time clock to 1:15:00 pm, June 17, 2013.

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	TT2013/06/17, 13:15:00 sets the real-time clock to 1:15:00 pm, June 17, 2013.

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.

Water Profiling Commands

These commands define the criteria used to collect the water-profile data.

Water Profiling is a feature upgrade for Navigator DVLs (see Feature Upgrades). Contact TRDI for information on how to install Water Profiling capability in your Navigator.

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 = 0088 ---------------- 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
WM = 1 ------------------- Profiling Mode (1-8)
WN = 030 ----------------- Number of depth cells (1-128)
WP = 00000 --------------- Pings per Ensemble (0-16384)
WQ = 0 ------------------- Sample Ambient Sound (0=OFF,1=ON)
WR = 04 ------------------ Mode 6 Transmit Percent
WS = 0200 ---------------- Depth Cell Size (cm)
WT = 0000 ---------------- Transmit Length (cm) [0 = Bin Length]
WV = 175 ----------------- Mode 1 Ambiguity Vel (cm/s radial)
WW = 004 ----------------- Mode 1 Pings before Mode 4 Re-acquire
WX = 999 ----------------- Mode 4 Ambiguity Vel (cm/s radial)
WZ = 010 ----------------- Mode 5 Ambiguity Velocity (cm/s radial)
>
```

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.

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 38: 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 WC064

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.

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 and process. The DVL always collects header data, fixed and variable leader data, and checksum data. Setting a bit to one tells the DVL to collect and process 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.

1. Each bit can have a value of one or zero. Setting a bit to one means output data, zero means suppress data.
2. This command selects which data is recorded if recording is enabled via the CF command.
3. If WP = zero, the DVL does not collect water-profile data.
4. Spaces in the command line are allowed.
5. 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 WE1000

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 WF0176 (300 kHz), WF0088 (600 kHz), WF0044 (1200 kHz)

Recommended Setting. Use Table 39, page203 to set the WF command.

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. The following table may be used as a guide to set the WF command.

Table 39. WF-command Recommended Setting

Frequency (kHz)	1000m Rated	1500m Rated	3000m Rated	6000m Rated
1200	1m	n/a	n/a	1m
600	2m	n/a	n/a	2m
300	3.5m	n/a	n/a	3.5m

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 WL001,005

Recommended Setting. The default setting for this command is recommended for most applications.

Description 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.

WM - Profiling Mode

Purpose Selects the application-dependent profiling mode used by the DVL.

Format WMn

Range n = 1, 5, 8 (see description)

Default WM1

Recommended Setting. The default setting for this command is recommended for most applications.

Description The WM command selects 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 40: 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

Water Modes 5 and 8 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.

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

FSAs are available for download at www.rdinstruments.com, Customer Support page.

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 128 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.

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

	300 kHz	600 kHz	1200 kHz
Range	20 to 1600 cm	10 to 800 cm	5 to 400 cm
Default	WS0400	WS0200	WS0100

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.

Setting 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 300 kHz system, the Navigator uses a value of 20 cm for WS. Similarly, if you enter WS8000, the Navigator uses a value of 1600 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 than 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) * 1.5

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.

1.5 = a safety factor.

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 41: 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.

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).

WW - WT Mode 1 Pings before Mode 4 Re-Acquire

Purpose	Sets the number of Mode 1 pings sent before a Mode 4 ping is attempted.
Format	WW*nnn*
Range	*nnn* = 0 to 999 pings
Default	WW004

Recommended Setting. The default setting for this command is recommended for most applications.

Description: WW is the number of Mode 1 pings generated by the ADCP before a Mode 4 ping is tried. The ADCP uses this value when Mode 4 is in use and the bottom is lost. If WW=0, the ADCP continually tries to generate Mode 4 pings.

WX - WT Mode 4 Ambiguity Velocity

Purpose	Sets the minimum radial ambiguity velocity for profiling Mode 4 (WM4).
Format	WX*nnn*
Range	*nnn* = 2 to 600 cm/s; 999 = auto-select
Default	WX999

Recommended Setting. The default setting for this command is recommended for most applications.

Description: Set WX as low as possible to attain maximum performance, but not too low or ambiguity errors will occur. WX999 tells the ADCP to select the best ambiguity velocity for the selected depth cell size (WS).

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	WZ010

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.

Chapter 9

Output Data Format

In this chapter, you will learn:

- Binary PD0 output data format
- Special Output Data Formats
- How to decode an ADCP ensemble

PD0 Output Data Format

The following description is for the standard PD0 Navigator output data format. Figure 57 through Figure 64 shows the binary data formats for the Navigator PD0 mode. Table 42 through Table 52 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 42). The fixed and variable leader data is preceded by ID codes 0000 and 8000, (explained in Figure 58 and Table 44). The Navigator always collects Header and Leader. Bottom Track data is preceded by ID codes 0600 (explained in Table 50).

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 (57 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 56. PD0 Standard Output Data Buffer Format

Water Profiling is a feature upgrade for Navigator DVLs (see Installing Feature Upgrades). 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)
 57   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)
-----------------------------------------------------------
833   BYTES OF DATA PER ENSEMBLE
```

VmDas may add additional bytes.

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.

Header Data Format

BYTE	BIT POSITIONS 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 42 for a description of the fields.

Figure 57. Binary Header Data 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 42: 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 64).
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 / Off-set 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 / Off-set 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).

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
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

BYTE	BIT POSITIONS 7 6 5 4 3 2 1 0	
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	SYSTEM POWER {CQ}	
54	SPARE	
55	INSTRUMENT SERIAL NUMBER	
↓		
58		
59	BEAM ANGLE	

See Table 43 for a description of the fields

Figure 58. Fixed Leader Data 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 43: 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 WorkHorse ADCP 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).
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 WorkHorse ADCP 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 WorkHorse ADCP does not make this validity check. Table 48 (Percent-Good Data Format) has more information.
19,20	10	WN / Number of Cells	Contains the number of depth cells over which the WorkHorse ADCP 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 WorkHorse ADCP does not collect the WD water-profile data. Note: The WorkHorse ADCP 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)

Table 43: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description
29-32	15,16	WF / Blank after Transmit	Contains the blanking distance used by the WorkHorse ADCP 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 WorkHorse ADCP 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 WorkHorse ADCP automatically extends the ensemble interval (set by TE) if (WP x TP > TE).
51,52	26	EX / Coord Transform	Contains the coordinate transformation processing parameters (EX-command). These firmware switches indicate how the DVL collected data. 00xxx = NO TRANSFORMATION (BEAM COORDINATES) 01xxx = INSTRUMENT COORDINATES 10xxx = SHIP COORDINATES 11xxx = EARTH COORDINATES xx1xx = TILTS (PITCH AND ROLL) USED IN SHIP OR EARTH TRANSFORMATION xxx1x = 3-BEAM SOLUTION USED IF ONE BEAM IS BELOW THE CORRELATION THRESHOLD SET BY THE WC-COMMAND xxxx1 = 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

Table 43: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description
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 WorkHorse ADCP uses the manual command setting. If the field = 1, the WorkHorse ADCP 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 WorkHorse ADCP 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)
69-72	35,36	WT Xmit pulse length	This field, set by the WT-command, contains the length of the transmit pulse. When the WorkHorse ADCP receives a <BREAK> signal, it sets the transmit pulse length as close as possible to the depth cell length (WS-command). This means the WorkHorse ADCP 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.
101-104	51-52	WB / System Bandwidth	Contains the WB-command setting. Range = 0 to 1
105-106	53	System Power	Contains the CQ-command setting for WorkHorse ADCP Monitor/Sentinel/Long Ranger ADCPs. Range 0 to 255.
107-108	54	Spare	Spare
109-116	55-58	Serial #	Instrument serial number
117 -118	59	Beam Angle	Beam angle

Variable Leader Data Format

BYTE	BIT POSITIONS 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								

BYTE	7	6	5	4	3	2	1	0	
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								

See Table 44 for a description of the fields.

Figure 59. Variable Leader Data 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 44: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	VID / Variable Leader ID	Stores the Variable Leader identification word (80 00h).

5-8	3,4	Ens / Ensemble Number	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.`

9,10	5	RTC Year	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.
11,12	6	RTC Month	
13,14	7	RTC Day	
15,16	8	RTC Hour	
17,18	9	RTC Minute	
19,22	10	RTC Second	
21,22	11	RTC Hundredths	
23-24	12	Ensemble # MSB	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.

25-28	13,14	BIT / BIT Result	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`

29-32	15,16	EC / 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
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 65535 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

Table 44: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
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 59,60 61,62	29 30 31	MPT minutes MPT seconds MPT hundredths	This field contains the Minimum Pre-Ping Wait Time between ping groups in the ensemble.
63,64 65,66 67,68	32 33 34	H/Hdg Std Dev P/Pitch Std Dev R/Roll 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°

69-70
71-72
73-74
75-76
77-78
79-80
81-82
83-84
	35
	36
	37
	38
	39
	40
	41
	42
		ADC Channel 0
		ADC Channel 1
		ADC Channel 2
		ADC Channel 3
		ADC Channel 4
		ADC Channel 5
		ADC Channel 6
		ADC Channel 7
			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, than:
			`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.

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), than it indicates that both 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 excep-`
			`tion`
			`     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`

Table 44: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
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 23 22 21 20 19 18 17 16 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
91-92	46		High 16 BITS MSB BITS 31 30 29 28 27 26 25 24 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). Scaling: LSD=1 deca-pascal; Range=0 to +- 2147483648 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 +- 2147483648 deca-pascals
113-114	57	Spare	Spare

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 45 for description of fields

Figure 60. Velocity Data Format

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
00xxx	BEAM	TO BEAM 1	TO BEAM 2	TO BEAM 3	TO BEAM 4
01xxx	INST	Bm1-Bm2	Bm4-Bm3	TO XDUCER	ERR VEL
10xxx	SHIP	PRT-STBD	AFT-FWD	TO SURFACE	ERR VEL
11xxx	EARTH	TO EAST	TO NORTH	TO SURFACE	ERR VEL

POSITIVE VALUES INDICATE WATER MOVEMENT

Table 45: 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.

Correlation Magnitude Echo Intensity, Percent-Good, and Status 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								

Table 48 for a description of the fields.

Figure 61. Binary Correlation Magnitude, Echo Intensity, and Percent-Good Data Format

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 46: 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 47: 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	Coordinate System	Velocity 1	Velocity 2	Velocity 3	Velocity 4
		Percentage Of Good Pings For:			
00xxx	Beam	Beam 1	BEAM 2	BEAM 3	BEAM 4

EX-Command	Coordinate System	Velocity 1	Velocity 2	Velocity 3	Velocity 4
		Percentage Of:			
01xxx 10xxx 11xxx	Instrument Ship Earth	3-Beam Transformations (note 1)	Transformations Rejected (note 2)	More Than One Beam Bad In Bin	4-Beam Transformations

Note 1. Because profile data did not exceed correlation threshold (WC command).

Note 2. Because the error velocity threshold was exceeded (WE command).

At the start of the velocity profile, the backscatter echo strength is typically high on all four beams. Under this condition, the DVL 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 DVL to reject some of its depth cell data. This causes the DVL to calculate velocities with three beams instead of four beams. When the DVL does 3-beam solutions, it stops calculating the error velocity because it needs four beams to do this. At some further depth cell, the DVL 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 neither 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:

Field 1 – Percentage of good 3-beam solutions – Shows percentage of successful velocity calculations (50%) using 3-beam solutions because the correlation threshold (WC command) was not exceeded.

Field 2 – Percentage of transformations rejected – 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 DVL 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 48: 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.

These fields contain information about the status and quality of DVL data. A value of 0 means the measurement was good. A value of 1 means the measurement was bad.

Table 49: Status Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the status data identification word (00 05h).
5,6	3	Depth cell 1, Field 1	Stores status data for depth cell #1, beam #1. See above.
7,8	4	Depth cell 1, Field 2	Stores status data for depth cell #1, beam #2. See above.
9,10	5	Depth cell 1, Field 3	Stores status data for depth cell #1, beam #3. See above.
11,12	6	Depth cell 1, Field 4	Stores status data for depth cell #1, beam #4. See above.
13-1028	7-514	Depth cell 2 – 128 (if used)	These fields store status 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.

Binary Bottom-Track Data Format

BYTE	BIT POSITIONS 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
33	BEAM#1 BT CORR.								
34	BEAM#2 BT CORR.								
35	BEAM#3 BT CORR.								
36	BEAM#4 BT CORR.								

BYTE	7/S	6	5	4	3	2	1	0	
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								
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

BYTE	7/S	6	5	4	3	2	1	0	
	BIT POSITIONS								
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 62. Binary Bottom-Track Data Format

This data is output only if the BP-command is > 0 and PD0 is selected. See Table 50 for a description of the fields.

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) 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 50: 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 command (coordinate system) 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 Scaling: LSD = 1 mm/s; Range = -10,000mm/s to +10,000mm/s
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.
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). Scaling (minimum layer size): LSD = 1 dm; Range = 0-999 dm Scaling (near/far boundaries): LSD = 1 dm; Range = 0-9999 dm

Table 50: Bottom-Track Data Format

Hex Digit	Binary Byte	Field	Description
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 45). 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). 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.
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

Binary Reserved BIT Data Format

BYTE	7	6	5	4	3	2	1	0	
1	RESERVED FOR TRDI USE								LSB
2									MSB

Figure 63. Binary Reserved BIT Data Format

The data is always output. See Table 51 for a description of the fields.

Table 51: 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).

Binary Checksum Data Format

BYTE	7	6	5	4	3	2	1	0	
	BIT POSITIONS								
1	CHECKSUM DATA								LSB
2									MSB

Figure 64. Binary Checksum Data Format

The data is always output. See Table 52 for a description of the fields.

Table 52: 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.

Special Output Data Formats

The PD3, PD4, PD5, PD6, PD10, PD11, PD13, PD22 and PD24 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 65 through Figure 67 shows the format of these buffers and the sequence in which the DVL sends the data. Table 58 lists the format, bytes, fields, scaling factors, and a detailed description of every item in the DVL binary output buffers.

The DVL output data formats are available with or without bottom-track. However, if bottom-track is not available, they will contain no data.

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) assumes that the instrument is stationary and the bottom is moving.

DVL Binary Data Format (PD3)

Byte	BIT POSITION 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									
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 65. DVL Binary Data Format (PD3)

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 53: 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	Data Structure	These byte contains the Data Structure.
			`Bit #`
			`0 = Ship or Earth BT Velocity`
			`1 = Vertical BT Velocity`
			`2 = Water Velocity`
			`3 = Beam Vertical Range to Bottom`
			`4 = Average Vertical Range to Bottom`
			`5 = Reserved`
			`6 = Reserved`
			`7 = Sensor/Other Data Byte`

5-8	3,4	X-Vel Btm	† Bit #0: Always output. If the data bit is set to 0, than Ship coordinates are used. If the data bit is set to 1, than 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

Table 53: DVL Output Data Format (PD3) Details

Hex Digit	Binary Byte	Field	Description
29-32 33-36 37-40 41-44	15,16 17,18 19,20 21,22	Bm1 Bm2 Rng to Bm3 Bottom Bm4	† 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. 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.
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.

† This block of data is only output if the bit is set to 1 in the Data Structure byte.

‡ This block of data is only output if the bit is set to 1 in the Sensor/Other Data byte.

DVL Binary Data Format (PD4/PD5)

Byte	BIT POSITION 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		
29	E-VEL REF LAYER	
30		
31	REF LAYER START	
32		
33	REF LAYER END	
34		
35	REF LAYER STATUS	

Byte	BIT POSITION							
	7	6	5	4	3	2	1	0
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 66. DVL Binary Data Format (PD4/PD5)

*If 0, than PD4 (Bytes 1-47)
*If 1, than PD5 (Bytes 1-45 + Table 55)

DVL Output Data Format (PD4/PD5) Details

The DVL sends this data format only when the PD4 or PD5 command is used.

Table 54: 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 66. 1 = PD5 = Bytes 1 through 45 from Figure 66 and bytes 46 through 88 from Figure 67. Note: PD6 is ASCII-only; see Table 56.
5-8	3,4	No. of Bytes	Contains the number of bytes sent in this data structure, not including the final check-sum.

Table 54: DVL Output Data Format (PD4/PD5) Details

Hex Digit	Binary Byte	Field	Description
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 15-18 19-22 23-26	6,7 8,9 10,11 12,13	X-Vel Btm Y-Vel Btm Z-Vel Btm E-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).
27-30 31-34 35-38 39-42	14,15 16,17 18,19 20,21	Bm1 Bm2 Rng to Bm3 Bottom Bm4	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. Scaling: LSD = 1 centimeter; Range = 0 to 65535 cm
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 49-52 53-56 57-60	23,24 25,26 27,28 29,30	Velocity 1 Velocity 2 Velocity 3 Velocity 4	These fields contain the velocity of the vessel in relation to the water-mass reference layer in mm/s. The setting of the EX-command (Coordinate Transformation) determines how the Navigator references the velocity data.

EX-CMD	COORD SYS	Velocity 1	Velocity 2	Velocity 3	Velocity 4
00xxx	Beam	To Beam 1	To Beam 2	To Beam 3	To Beam 4
01xxx	Instrument	Bm1-Bm2	Bm4-Bm3	To Xducer	Err Vel
10xxx	Ship	Port-Stbd	Aft-Fwd	To Surface	Err Vel
11xxx	Earth	To East	To North	To Surface	Err Vel

Positive values indicate water movement (see notes at end of this table).

Hex Digit	Binary Byte	Field	Description
61-64 65-68	31,32 33,34	Ref Layer Start Ref Layer End	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
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

Table 54: DVL Output Data Format (PD4/PD5) Details

Hex Digit	Binary Byte	Field	Description
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
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 55.

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 than 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.

DVL Binary Data Format (PD5)

Byte	7	6	5	4	3	2	1	0	
	BIT POSITION								
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
75	DISTANCE MADE GOOD/REF (NORTH)								LSB
76									
77									
78									MSB
79	DISTANCE MADE GOOD/REF (UP)								LSB
80									
81									

Byte	BIT POSITION 7	6	5	4	3	2	1	0	
82									MSB
83	DISTANCE MADE GOOD/REF (ERROR)								LSB
84									
85									
86									MSB
87	CHECKSUM								LSB
88									MSB

Figure 67. DVL Binary Data Format (PD5)

DVL Output Data Format (PD5) Details

The DVL sends this data format (Figure 66 and Figure 67) only when the PD5 command is used. Table 54 explains the first part of this data structure.

Table 55: 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
109-116 117-124 125-132 133-140	55-58 59-62 63-66 67-70	DMG/Btm East DMG/Btm North DMG/Btm Up DMG/Btm Error	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
141-148 149-156 157-164 165-172	71-74 75-78 79-82 83-86	DMG/Ref East DMG/Ref North DMG/Ref Up DMG/Ref Error	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
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.

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 56: 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)

Table 56: DVL Output Data Format (PD6)

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
```

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
48	PITCH								LSB

BYTE	BIT POSITION 7 6 5 4 3 2 1 0	
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 68. DVL Binary Data Format (PD10)

Navigator DVLs must have firmware 9.13 or later in order to use PD10 Output Data Format.

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.

Navigator DVLs must have firmware 9.13 or later in order to use PD10 Output Data Format.

Table 57: 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, than Ship coordinates are used. If the data bit is set to 1, than 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 33-36 37-40 41-44	15,16 17,18 19,20 21,22	Bm1 Bm2 Rng to Bm3 Bottom Bm4	† 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. 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.
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 Temperature in hundredths of degrees.

Table 57: DVL Output Data Format (PD10) Details

Hex Digit	Binary Byte	Field	Description

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.

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.

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.

TRDI may add additional sentences in the future so care should be taken to correctly identify the sentence by its 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>
```

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 58: 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)

Table 58: DVL Output Data Format (PD13)

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

How to Decode a DVL Ensemble

Use the following information to help you write your own software.

Rules for the BroadBand Data Format PD0

1. 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 59: 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

2. 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".
3. 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 than it must be added to the end of the data string (bytes 54-x as an example).
4. 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.
5. The header data will include the number of data types in the files and the offset to each ID number for each data type.
6. 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 Broad-Band 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. This will be your offset to the next ensemble.
    b. 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.
    c. Read the 2-byte checksum word at the end of the ensemble, located by using the checksum offset in the header (determined in step “2-a”) and compare this checksum word to the value calculated in step “2-b”.
    d. If the checksums match than you have a valid ensemble. If the checksums do not match than you do not have a valid ensemble and you need to 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.

Chapter 10

SPECIFICATIONS

In this chapter, you will learn:

- What are the Navigator specifications
- Navigator dimensions and weights

A brief review of DVL operation may help you understand the specifications listed in this section.

> 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:

1. All these specifications assume minimal DVL motion - pitch, roll, heave, rotation, and translation.
2. 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.
3. 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.
4. 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 60: Navigator Bottom Velocity

Single-ping Precision	300 kHz	600 kHz	1200 kHz
Standard deviation at 1.0 m/s[1]	±0.3cm/s	±0.3 cm/s	±0.3 cm/s
Standard deviation at 3.0 m/s[1]	±0.6 cm/s	±0.5 cm/s	±0.4 cm/s
Standard deviation at 5.0 m/s[1]	±0.8 cm/s	±0.6 cm/s	±0.5 cm/s
Long-Term Accuracy	±0.4% ± 0.2 cm/s	±0.3% ±0.1 cm/s	±0.2% ±0.1 cm/s
Minimum Altitude (m)[2]	1.0	0.7	0.5 (0.25 optional)
Maximum Altitude (m)[2]	200	90	30

[1] Standard deviation refers to single-ping horizontal velocity, specified at half the maximum altitude.

[2] @5°C and 35 ppt, 42VDC.

Table 61: Navigator Velocity Range

Parameters	300 kHz	600 kHz	1200 kHz
Velocity range[1]	±10m/s	±10m/s	±10m/s
Velocity resolution	0.1cm/s	0.1cm/s	0.1cm/s
Ping Rate	7 Hz max	7 Hz max	7 Hz max

[1] Maximum bottom-tracking range may be reduced due to flow noise at high speed and/or cavitation.

Table 62: Navigator Water Reference Velocity

Parameters	300 kHz	600 kHz	1200 kHz
Accuracy	±0.4% ±0.2cm/s	±0.3% ±0.2cm/s	±0.2% ±0.1cm/s
Layer size	selectable	selectable	selectable
Minimum range	1m	0.7m	0.25m
Maximum range[1]	110m	50m	18m

[1] Reference layer maximum ranges are for typical water conditions: 35% salinity, 10°C temperature.

Table 63: 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

[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.

Table 64: Long Range Mode

	Range (m) @ 33VDC[1]	Range (m) @ 48VDC[1]	Depth Cell Size (m)	Std. dev. (mm/s)
1200kHz	19	20	2	35
600kHz	67	70	4	38
300kHz	165	175	8	38

[1] 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 65: Echo Intensity Profile

Item	Specification
Vertical resolution	Depth cell size
Dynamic range	80 dB
Precision	± 1.5dB (relative measure)

Table 66: Standard Sensors

Temperature (Transducer Mounted)	
Range	-5° to 45° C
Uncertainty	±0.4° C
Resolution	0.01°
Tilt	
Range	±15°
Uncertainty	±0.5° (up to 15°)
Precision	± 0.5°
Resolution	0.01°
Compass [1]	
Type	flux gate
Long-term accuracy	±2° @ 60° magnetic dip angle, 0.5G total field
Precision	± 0.50 @ 60° magnetic dip angle, 0.5G total field
Resolution	0.01°
Tilt	± 15°
Optional Pressure Sensor [2]	
Available Pressure Ratings	1, 2, 5, 10, 20, 50, 100, 200, 400, 500, or 1000 BAR
Short-term uncertainty	±0.1%
Max. drift	±0.25%

[1] Includes built-in field calibration procedure. Compass uncertainty is for tilts less than 15°.

[2] Other pressure ratings may be special-ordered.

Table 67: 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 Janus array		
Housing & Transducer material	6061 or 7075 Aluminum or Titanium		
External connector	7-pin low-profile		
Internal memory	Navigator DVLs can use optional memory cards (see PC Card Recorder). The maximum memory for each slot is 2GB, with the total memory capacity not to exceed 4GB.		
Communications	NMEA0183, ASCII or binary outputs at 1200–115,200 baud user-selectable; serial port is switch selectable for RS232 or RS422		
Trigger inputs	1) ASCII; 2) RDS3; 3) low latency		

Table 68: Environmental

Item	Specification
Standard depth rating	3000m (6000-meter housings available)
Navigator operating temperature	-5° to 45°C
Navigator storage temperature	-30° to 60°C
External battery case storage temperature (batteries installed)	-5° to 45°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.

Do not deploy the system with batteries that are older than the Warning date. It should be noted, that while a battery pack will not be dead after the Warning date, the actual performance of the battery is in doubt, and may not have sufficient capacity for the deployment.

TRDI batteries have four dates on them:

Manufacture Date is the date the battery was built and final tested.

TRDI Ship by Date provides the maximum duration that the battery will remain on our shelves before we will ship and is 6 months after our manufacture date.

Warning Do not Deploy After Date* provides the last date when the battery should be used to start a deployment and is 12 months from the manufacture date.

Expiration Date provides the date when the battery should no longer be considered useful and is 2 years from the manufacture date.

*A battery pack used to start a deployment prior to the Warning Date means that it will perform as expected and provide the required power for any deployment that was created using the TRDI planning module. 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 69: Power

System	300 kHz	600 kHz	1200 kHz
DC input	20 to 50 VDC external power supply		
Current	0.4A minimum power supply capability		
External Battery Pack	42 VDC (new), 28 VDC (depleted). Holds up to two 450 watt hour batteries		
Transmit[1]			
Peak power @ 24VDC	66w	21w	8w
Average power (typical)	8w	3w	3w

[1] @ 15% duty cycle at peak power (standby 1mW).

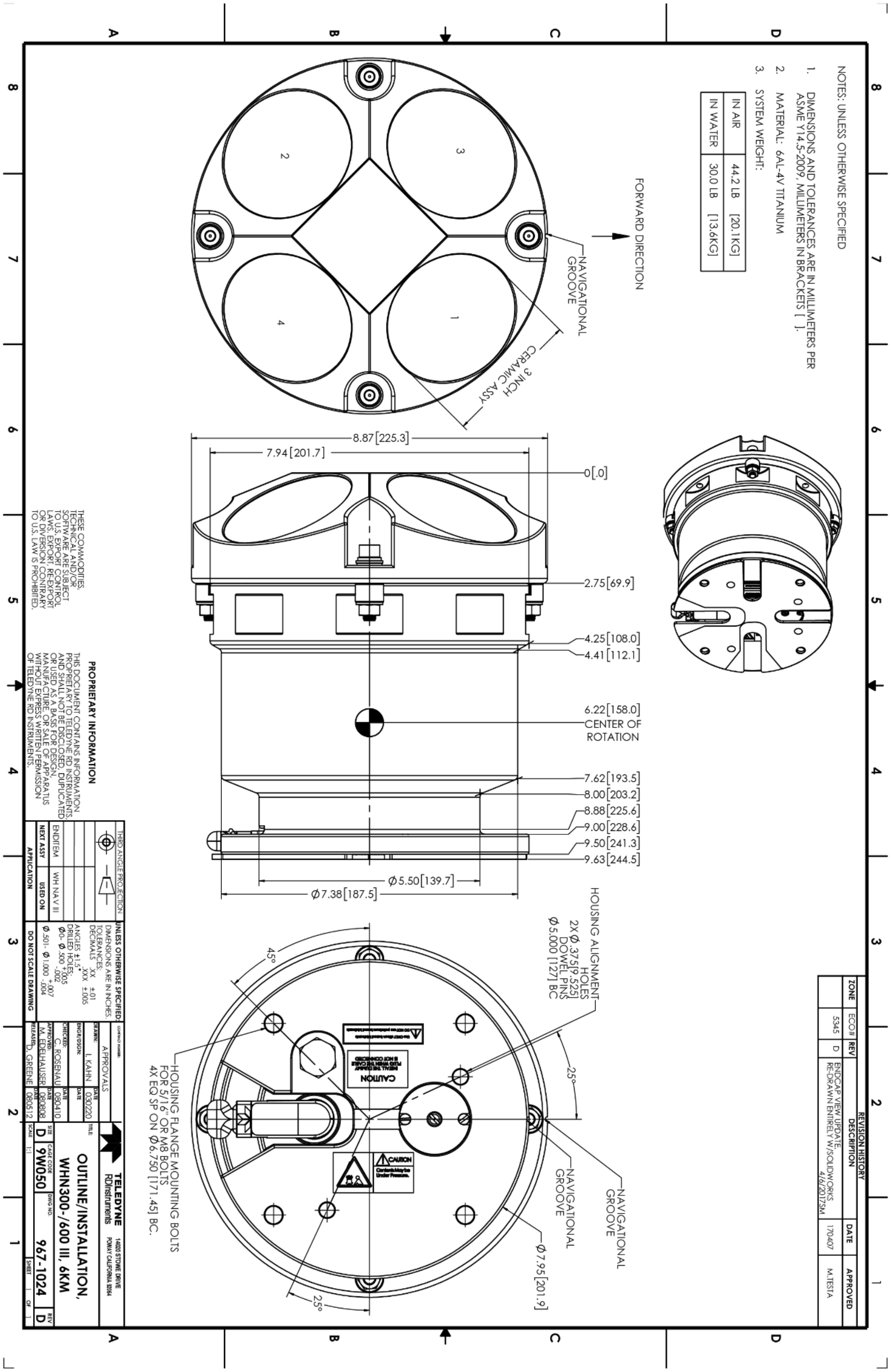
Outline Installation Drawings

The following drawings show the Navigator DVL dimensions and weights.

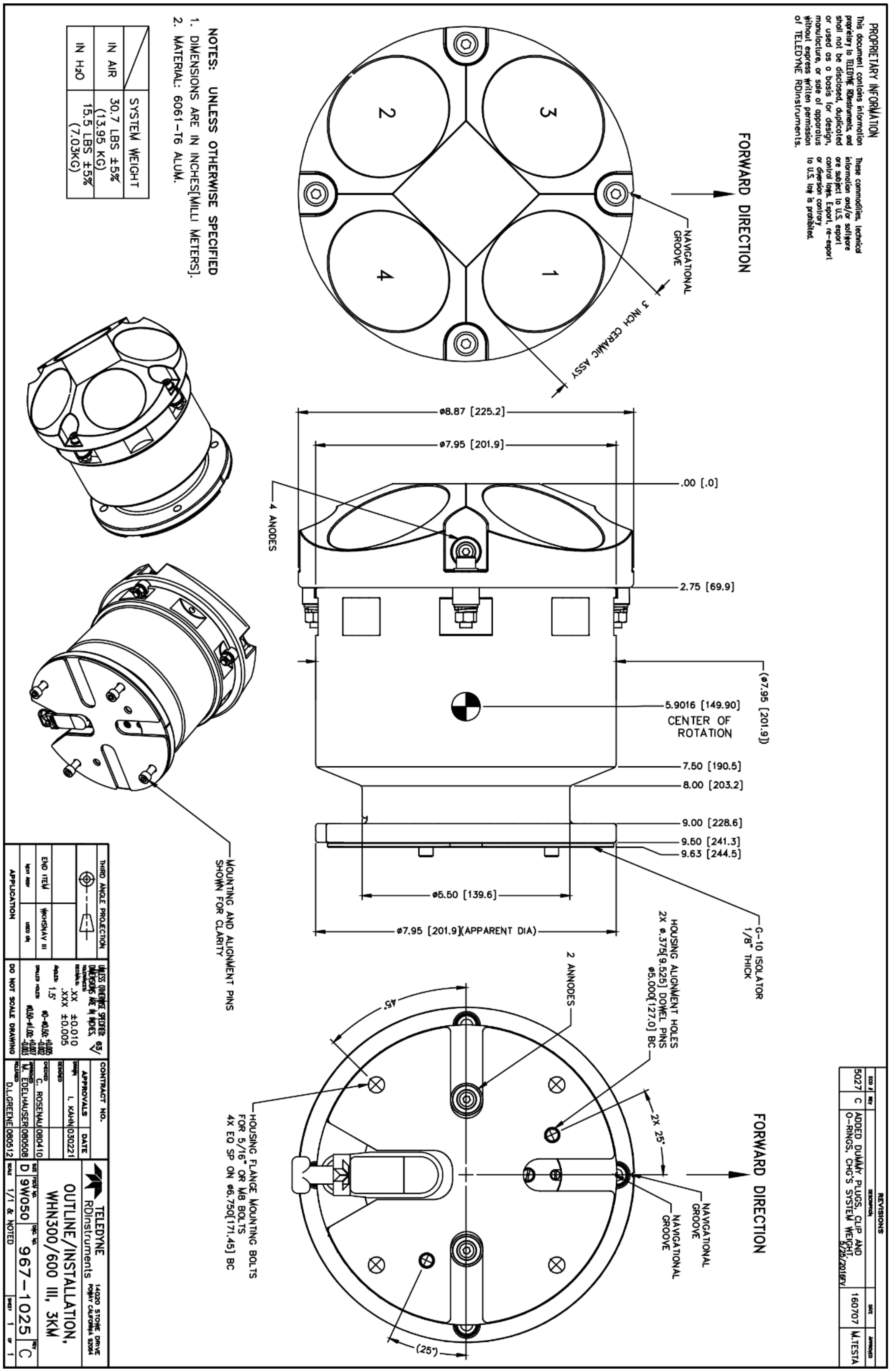
Table 70: Outline Installation Drawings

Description	Drawing #
300/600 kHz Navigator III, 6000 meter	967-1024 Rev. D
300/600 kHz Navigator III, 3000 meter	967-1025 Rev. C
1200 kHz Navigator III, 3000 meter	967-1026 Rev. C
1200 kHz Navigator III, 6000 meter	967-1027 Rev. D
300/600 kHz Navigator IV, 3000 and 6000 meter, modular beams	967-6141 Rev XB
1200 kHz Navigator IV, 3000 and 6000 meter, modular beams	967-6147 Rev XA
300/600 kHz Navigator V, 3000 and 6000 meter, modular beams, Small OD	967-6155 Rev XA
External Battery Case, 6000 meter	967-4001 Rev. XG

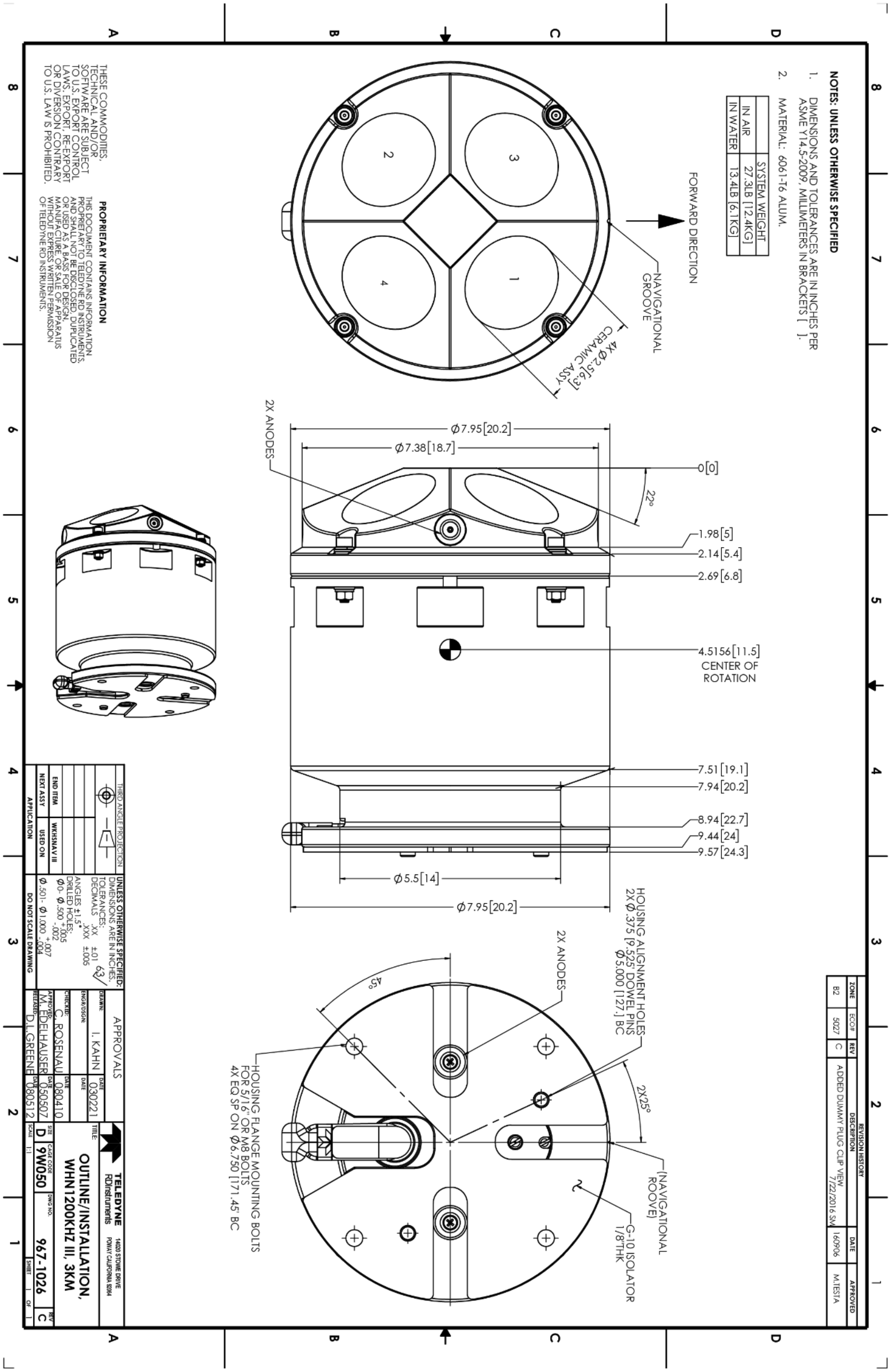
967-1024


NOTES: UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS AND TOLERANCES ARE IN MILLIMETERS PER ASME Y14.5-2009, MILLIMETERS IN BRACKETS [ ].
2. MATERIAL: 6AL-4V TITANIUM
3. SYSTEM WEIGHT:
IN AIR 44.2 LB [20.1KG]
IN WATER 30.0 LB [13.6KG]
FORWARD DIRECTION
NAVIGATIONAL GROOVE
3 INCH CERAMIC ASSY
8.87[225.3]
7.94[201.7]
0[.0]
2.75[69.9]
4.25[108.0]
4.41[112.1]
6.22[158.0]
CENTER OF ROTATION
7.62[193.5]
8.00[203.2]
8.88[225.6]
9.00[228.6]
9.50[241.3]
9.63[244.5]
Ø5.50[139.7]
Ø7.38[187.5]
HOUSING ALIGNMENT HOLES
2X Ø.375[9.525] DOWEL PINS
Ø5.000 [127] BC
HOUSING FLANGE MOUNTING BOLTS
FOR 5/16" OR M8 BOLTS
4X EQ SP ON Ø6.750 [171.45] BC.
45°
25°
Ø7.95[201.9]
CAUTION
PROPRIETARY INFORMATION
OUTLINE/INSTALLATION, WHN300-/600 III, 6KM
9W050
967-1024
TELEDYNE RD Instruments
DO NOT SCALE DRAWING
REVISION HISTORY
ENDCAP VIEW UPDATE
M.TESTA

967-1025


PROPRIETARY INFORMATION
This document contains information proprietary to TELEDYNE RDInstruments, and shall not be disclosed, duplicated or used as a basis for design, manufacture, or sale of apparatus without express written permission of TELEDYNE RDInstruments.
These commodities, technical information and/or software are subject to U.S. export control laws. Export, re-export or diversion contrary to U.S. law is prohibited.
FORWARD DIRECTION
NAVIGATIONAL GROOVE
3 INCH CERAMIC ASSY
NOTES: UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS ARE IN INCHES[MILLI METERS].
2. MATERIAL: 6061-T6 ALUM.
SYSTEM WEIGHT
IN AIR 30.7 LBS ±5% (13.95 KG)
IN H2O 15.5 LBS ±5% (7.03KG)
ø8.87 [225.2]
ø7.95 [201.9]
.00 [.0]
4 ANODES
2.75 [69.9]
(ø7.95 [201.9])
5.9016 [149.90]
CENTER OF ROTATION
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
2 ANODES
MOUNTING AND ALIGNMENT PINS SHOWN FOR CLARITY
HOUSING FLANGE MOUNTING BOLTS FOR 5/16" OR M8 BOLTS 4X EQ SP ON ø6.750[171.45] BC
2X 25°
45°
(25°)
REVISIONS
5027 C ADDED DUMMY PLUGS, CLIP AND O-RINGS, CHG'S SYSTEM WEIGHT. 160707 M.TESTA
THIRD ANGLE PROJECTION
END ITEM WHSHAV III
APPLICATION
DO NOT SCALE DRAWING
CONTRACT NO.
APPROVALS DATE
L. KAHN 030221
C. ROSENAU 080410
M. EDELHAUSER 080508
D.L.GREENE 080512
TELEDYNE RDInstruments 14020 STOWE DRIVE POWAY CALIFORNIA 92064
OUTLINE/INSTALLATION, WHN300/600 III, 3KM
D 9W050 967-1025 C
1/1 & NOTED SHEET 1 OF 1

967-1026


NOTES: UNLESS OTHERWISE SPECIFIED
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2. MATERIAL: 6061-T6 ALUM.
SYSTEM WEIGHT
IN AIR 27.3LB [12.4KG]
IN WATER 13.4LB [6.1KG]
FORWARD DIRECTION
NAVIGATIONAL GROOVE
4X Ø2.5[6.3] CERAMIC ASSY
2X ANODES
Ø7.95[20.2]
Ø7.38[18.7]
0[0]
22°
1.98[5]
2.14[5.4]
2.69[6.8]
4.5156[11.5] CENTER OF ROTATION
7.51[19.1]
7.94[20.2]
8.94[22.7]
9.44[24]
9.57[24.3]
Ø5.5[14]
Ø7.95[20.2]
HOUSING ALIGNMENT HOLES 2X Ø.375 [9.525] DOWEL PINS Ø5.000 [127.] BC
HOUSING FLANGE MOUNTING BOLTS FOR 5/16" OR M8 BOLTS 4X EQ SP ON Ø6.750 [171.45] BC
45°
2X 25°
(NAVIGATIONAL ROOVE)
G-10 ISOLATOR 1/8"THK
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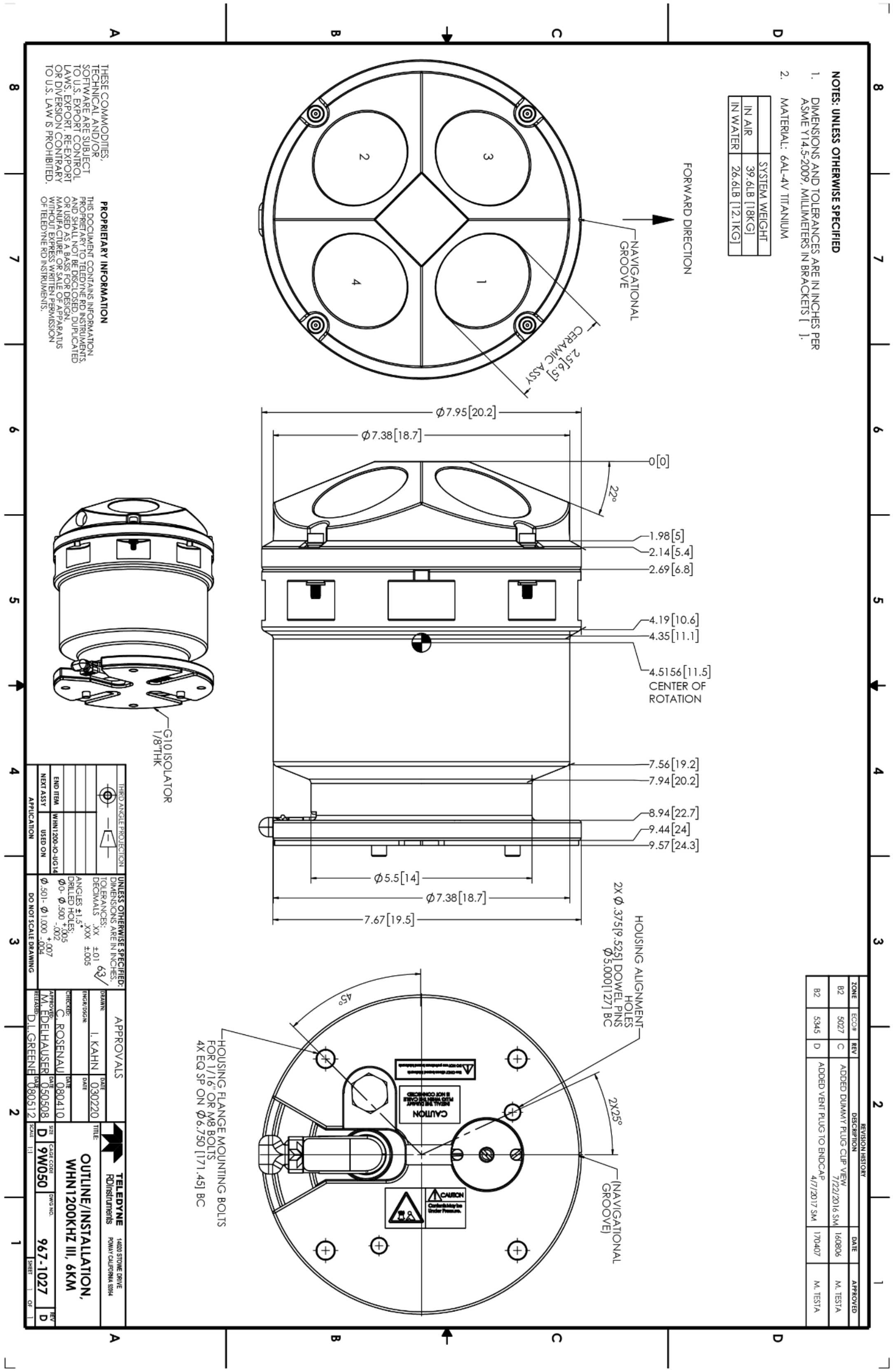
REVISION HISTORY
B2 5027 C ADDED DUMMY PLUG CLIP VIEW 7/22/2016 SM 160906 M.TESTA
APPROVALS
I. KAHN 030221
C. ROSENAU 080410
M. EDELHAUSER 050507
D.L.GREENE 080512
TELEDYNE RD Instruments
OUTLINE/INSTALLATION, WHN1200KHZ III, 3KM
D 9W050 967-1026 C
WKHSNAV III
DO NOT SCALE DRAWING

967-1027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2. MATERIAL: 6AL-4V TITANIUM
SYSTEM WEIGHT
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IN WATER 26.6LB [12.1KG]
FORWARD DIRECTION
NAVIGATIONAL GROOVE
CERAMIC ASSY
2.5[6.5]
Ø7.95[20.2]
Ø7.38[18.7]
0[0]
22°
1.98[5]
2.14[5.4]
2.69[6.8]
4.19[10.6]
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4.5156[11.5]
CENTER OF ROTATION
7.56[19.2]
7.94[20.2]
8.94[22.7]
9.44[24]
9.57[24.3]
Ø5.5[14]
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G10 ISOLATOR 1/8"THK
HOUSING ALIGNMENT HOLES
2X Ø.375[9.525] DOWEL PINS
Ø5.000[127] BC
HOUSING FLANGE MOUNTING BOLTS FOR 1/16" OR M8 BOLTS 4X EQ SP ON Ø6.750 [171.45] BC
45°
2X25°
(NAVIGATIONAL GROOVE)
CAUTION
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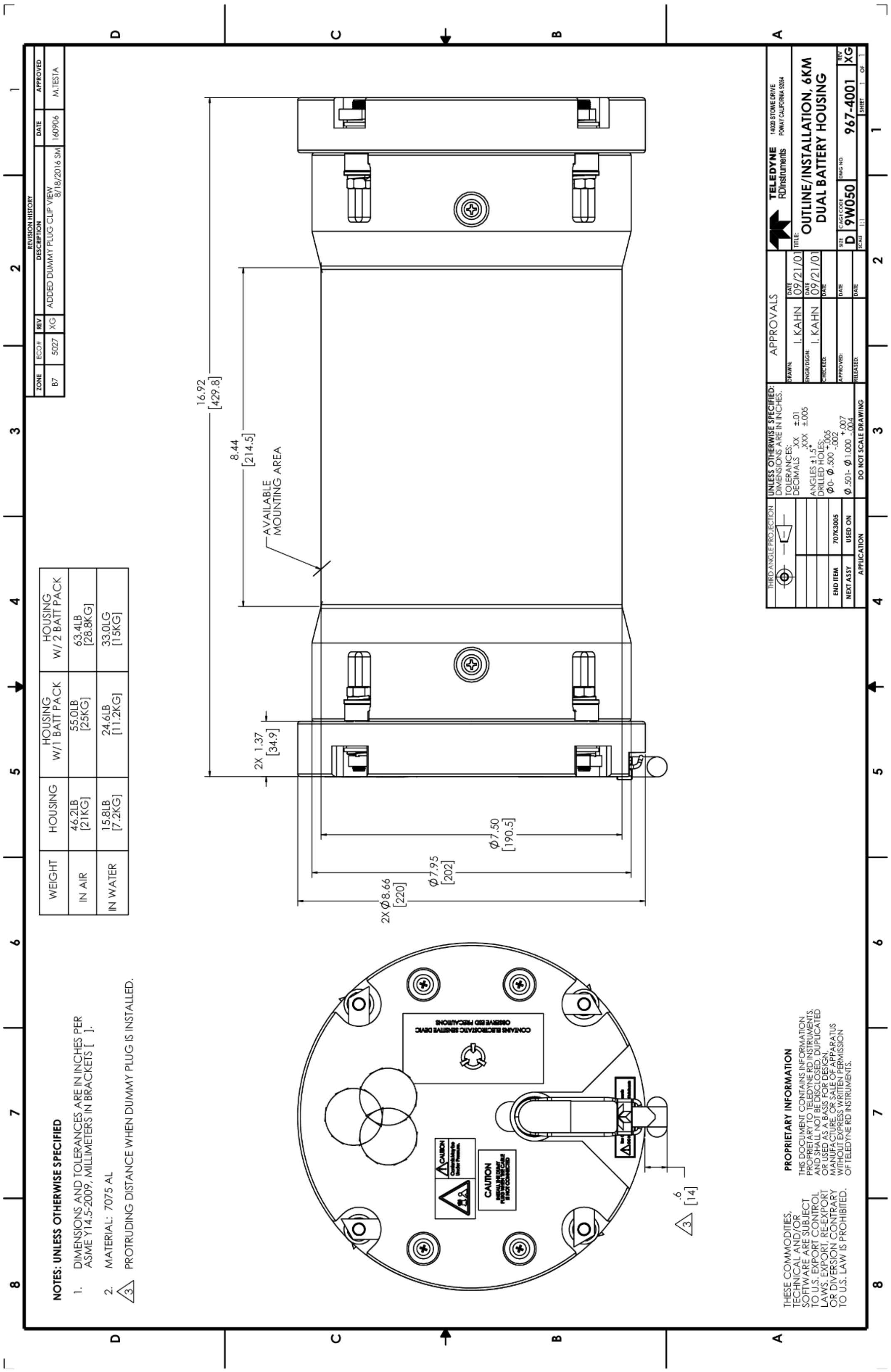
PROPRIETARY INFORMATION
REVISION HISTORY
ADDED DUMMY PLUG CLIP VIEW
ADDED VENT PLUG TO ENDCAP
M. TESTA
APPROVALS
I. KAHN
C. ROSENAU
M. EDELHAUSER
D. GREENE
TELEDYNE RD Instruments
OUTLINE/INSTALLATION, WHN1200KHZ III, 6KM
D 9W050 967-1027 D
DO NOT SCALE DRAWING

967-4001


NOTES: UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS AND TOLERANCES ARE IN INCHES PER ASME Y14.5-2009, MILLIMETERS IN BRACKETS [ ].
2. MATERIAL: 7075 AL
3 PROTRUDING DISTANCE WHEN DUMMY PLUG IS INSTALLED.
WEIGHT
HOUSING
HOUSING W/1 BATT PACK
HOUSING W/2 BATT PACK
IN AIR
46.2LB [21KG]
55.0LB [25KG]
63.4LB [28.8KG]
IN WATER
15.8LB [7.2KG]
24.6LB [11.2KG]
33.0LG [15KG]
REVISION HISTORY
ZONE
ECO #
REV
DESCRIPTION
DATE
APPROVED
B7
5027
XG
ADDED DUMMY PLUG CLIP VIEW 8/18/2016 SM
160906
M.TESTA
16.92 [429.8]
8.44 [214.5]
AVAILABLE MOUNTING AREA
2X 1.37 [34.9]
Ø7.50 [190.5]
Ø7.95 [202]
2X Ø8.66 [220]
.6 [14]
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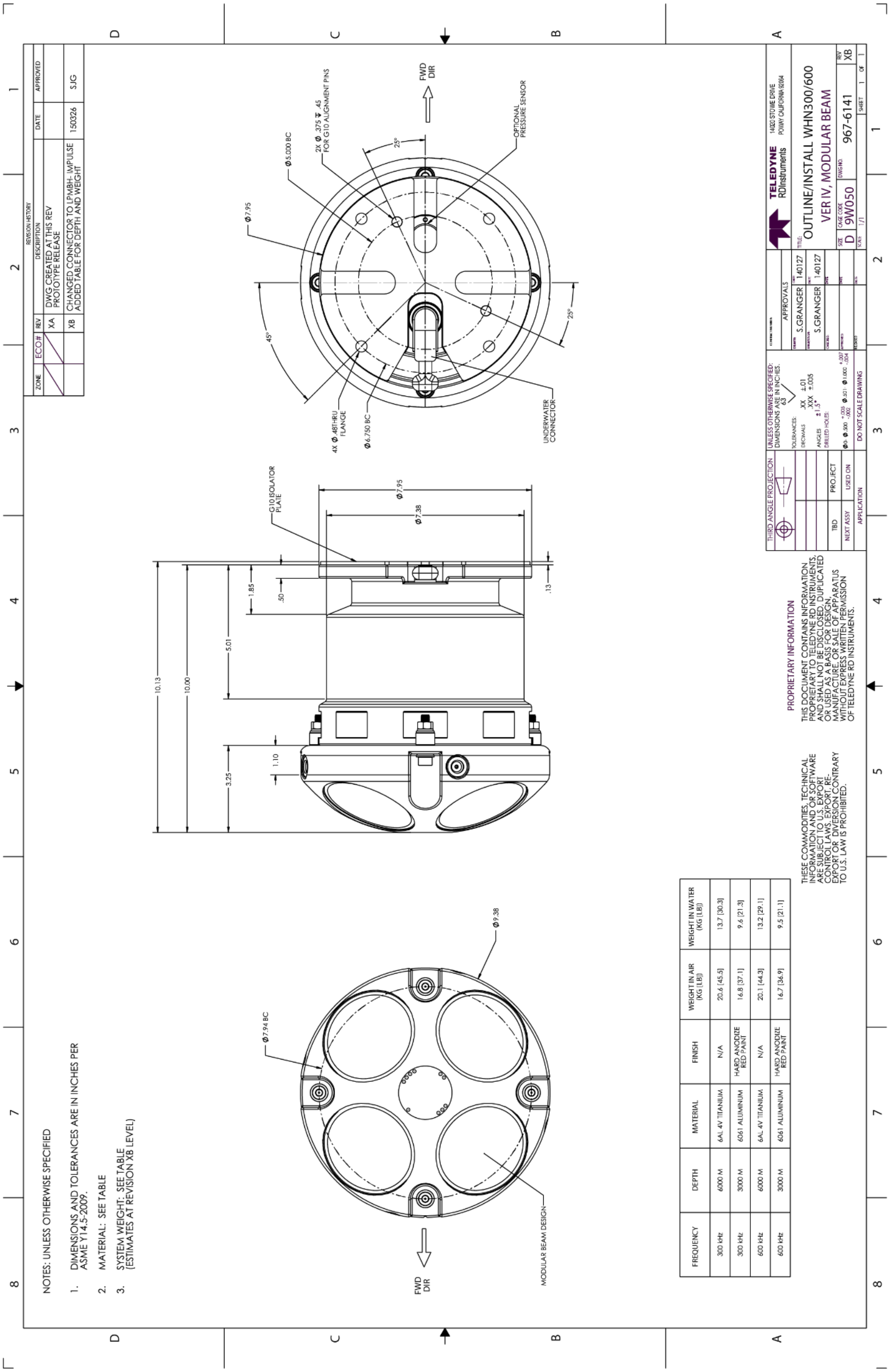
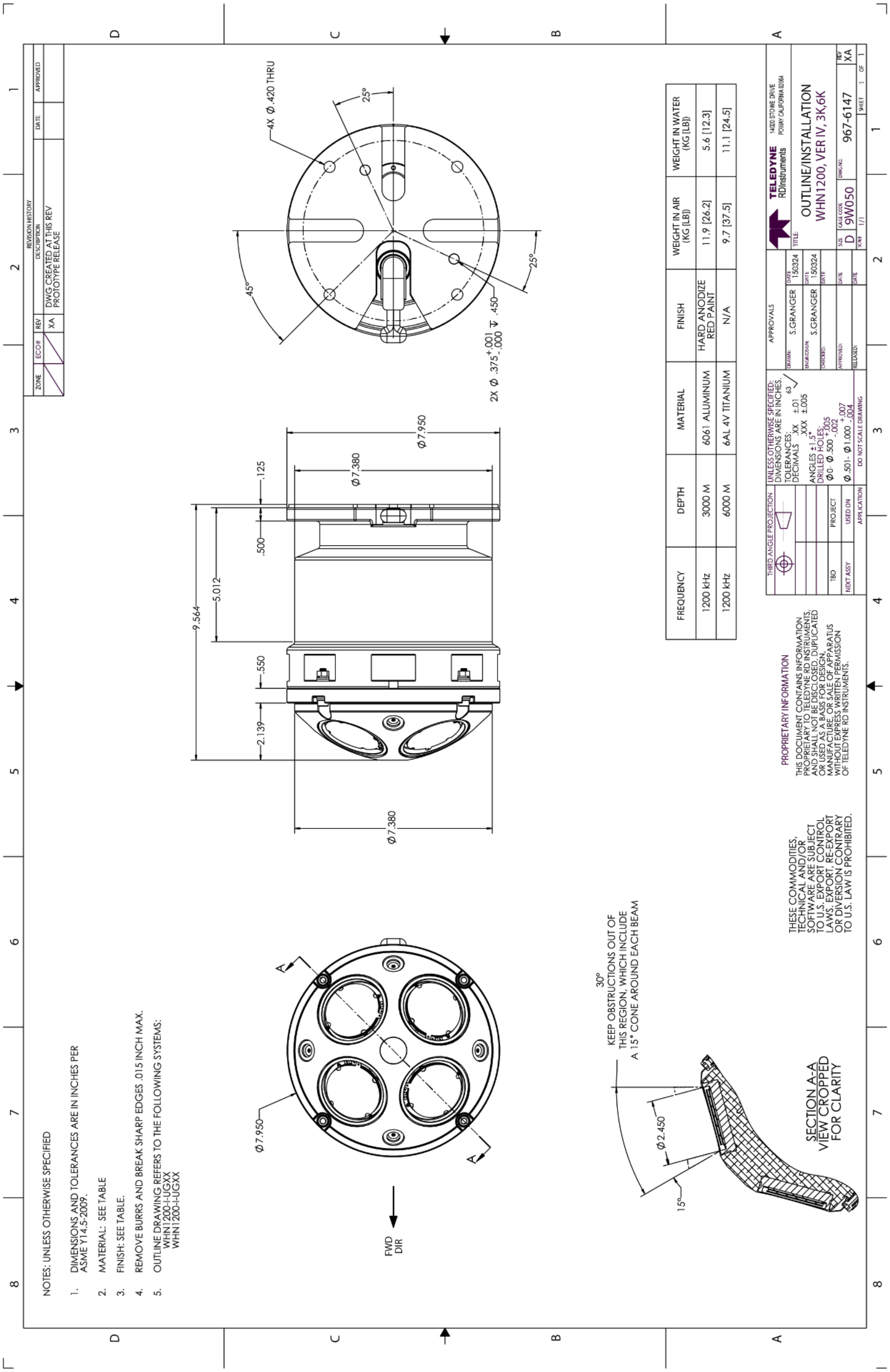
PROPRIETARY INFORMATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES.
DO NOT SCALE DRAWING
APPROVALS
DRAWN I. KAHN 09/21/01
ENGR/DSGN I. KAHN 09/21/01
TELEDYNE RD Instruments
OUTLINE/INSTALLATION, 6KM DUAL BATTERY HOUSING
D 9W050 967-4001 XG

967-6141



FREQUENCY	DEPTH	MATERIAL	FINISH	WEIGHT IN AIR (KG [LB])	WEIGHT IN WATER (KG [LB])
300 kHz	6000 M	6AL 4V TITANIUM	N/A	20.6 [45.5]	13.7 [30.3]
300 kHz	3000 M	6061 ALUMINUM	HARD ANODIZE RED PAINT	16.8 [37.1]	9.6 [21.3]
600 kHz	6000 M	6AL 4V TITANIUM	N/A	20.1 [44.3]	13.2 [29.1]
600 kHz	3000 M	6061 ALUMINUM	HARD ANODIZE RED PAINT	16.7 [36.9]	9.5 [21.1]

967-6147


NOTES: UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS AND TOLERANCES ARE IN INCHES PER ASME Y14.5-2009.
2. MATERIAL: SEE TABLE
3. FINISH: SEE TABLE.
4. REMOVE BURRS AND BREAK SHARP EDGES .015 INCH MAX.
5. OUTLINE DRAWING REFERS TO THE FOLLOWING SYSTEMS: WHN1200-I-UGXX WHN1200-I-UGXX
FREQUENCY | DEPTH | MATERIAL | FINISH | WEIGHT IN AIR (KG [LB]) | WEIGHT IN WATER (KG [LB])
1200 kHz | 3000 M | 6061 ALUMINUM | HARD ANODIZE RED PAINT | 11.9 [26.2] | 5.6 [12.3]
1200 kHz | 6000 M | 6AL 4V TITANIUM | N/A | 9.7 [37.5] | 11.1 [24.5]
4X Ø .420 THRU
25°
45°
2X Ø .375 +.001 -.000 ↧ .450
Ø7.950
Ø7.380
.125
.500
5.012
9.564
.550
2.139
FWD DIR
30°
KEEP OBSTRUCTIONS OUT OF THIS REGION, WHICH INCLUDE A 15° CONE AROUND EACH BEAM
Ø2.450
15°
SECTION A-A VIEW CROPPED FOR CLARITY
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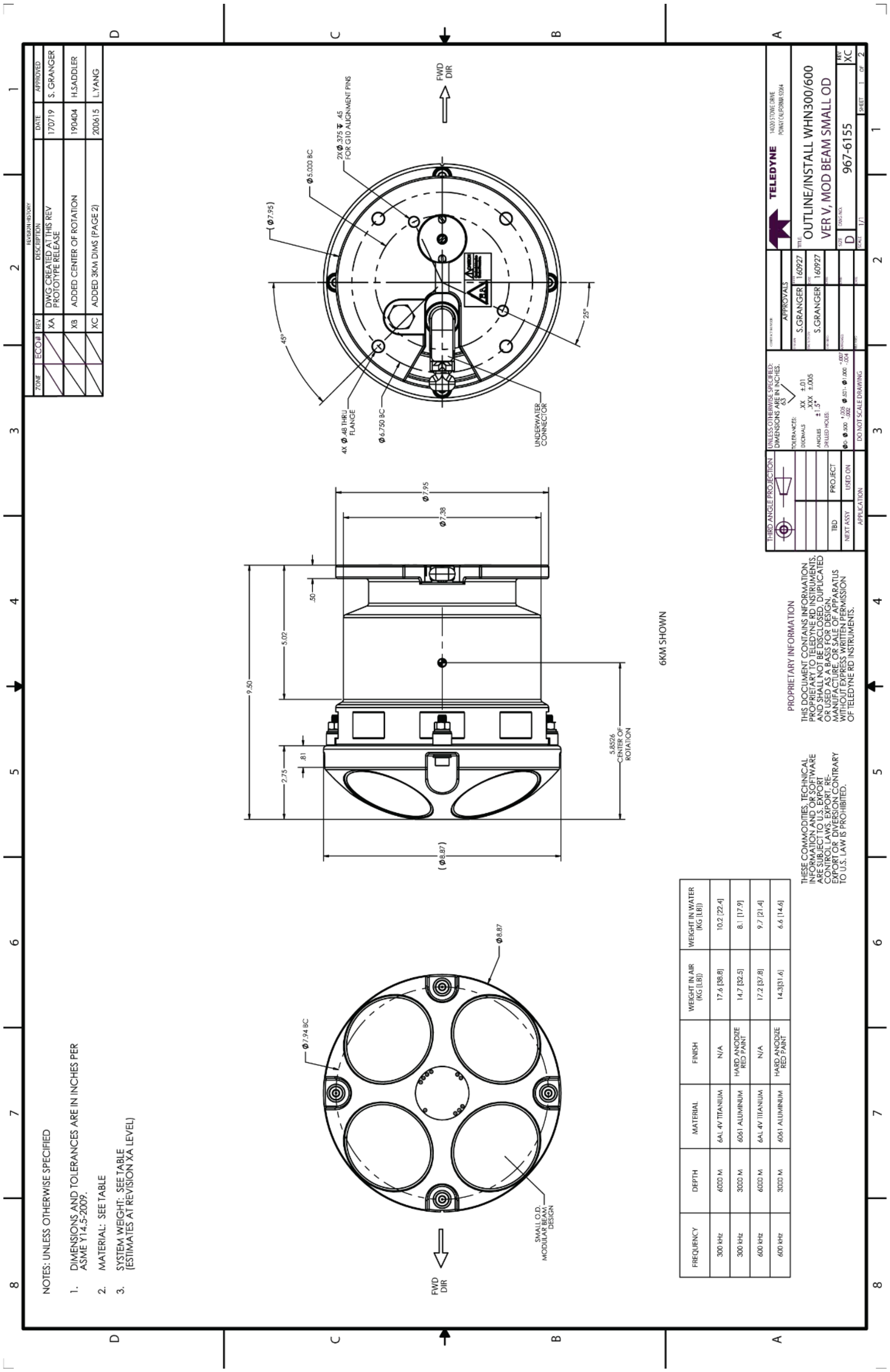
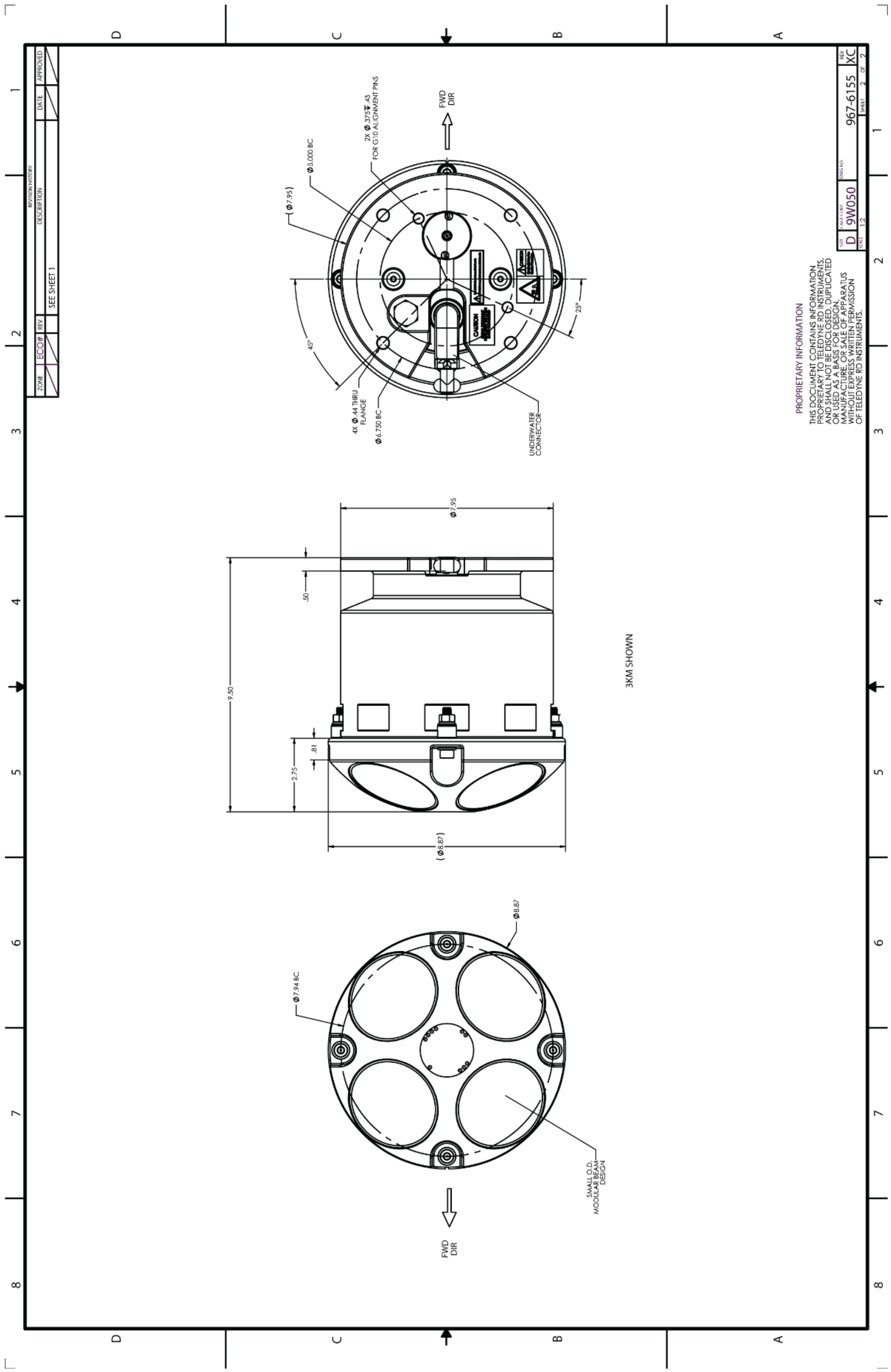
REVISION HISTORY
ZONE | ECO# | REV | DESCRIPTION | DATE | APPROVED
XA | DWG CREATED AT THIS REV PROTOTYPE RELEASE
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
TOLERANCES: DECIMALS .XX ±.01 .XXX ±.005
ANGLES ±1.5°
DRILLED HOLES: Ø0 - Ø.500 +.005 -.002
Ø.501 - Ø1.000 +.007 -.004
DO NOT SCALE DRAWING
THIRD ANGLE PROJECTION
APPROVALS
DRAWN: S.GRANGER 150324
ENGINEER: S.GRANGER 150324
TELEDYNE RD Instruments 14020 STOWE DRIVE POWAY CALIFORNIA 92064
OUTLINE/INSTALLATION WHN1200, VER IV, 3K,6K
SIZE D CAGE CODE 9W050 DWG NO 967-6147 REV XA
SCALE 1/1 SHEET 1 OF 1

967-6155



FREQUENCY	DEPTH	MATERIAL	FINISH	WEIGHT IN AIR (KG [LB])	WEIGHT IN WATER (KG [LB])
300 kHz	6000 M	6AL 4V TITANIUM	N/A	17.6 [38.8]	10.2 [22.4]
300 kHz	3000 M	6061 ALUMINUM	HARD ANODIZE RED PAINT	14.7 [32.5]	8.1 [17.9]
600 kHz	6000 M	6AL 4V TITANIUM	N/A	17.2 [37.8]	9.7 [21.4]
600 kHz	3000 M	6061 ALUMINUM	HARD ANODIZE RED PAINT	14.3[31.6]	6.6 [14.6]


FWD DIR
2X Ø .375 ▼ .45 FOR G10 ALIGNMENT PINS
Ø 5.000 BC
(Ø 7.95)
45°
25°
4X Ø .44 THRU FLANGE
Ø 6.750 BC
UNDERWATER CONNECTOR
Ø 7.95
.50
9.50
2.75
.81
(Ø 8.87)
3KM SHOWN
Ø 8.87
Ø 7.94 BC
SMALL O.D. MODULAR BEAM DESIGN
FWD DIR
ZONE
REV
ECO#
SEE SHEET 1
DESCRIPTION
REVISION HISTORY
DATE
APPROVED
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D
9W050
967-6155
XC
SCALE 1:2
SHEET 2 OF 2

NOTES

Appendix A

APPLICATION NOTES

In this chapter, you will learn:

- Design of a sea chest
- The Effect of a Moving Bottom Condition
- Vessel-Mounted ADCPs and Windows for Sea Chests
- Configuring Bottom Track Mode 6
- Shallow Water Bottom Tracking Bottom Mode 7
- Using NMEA Heading Strings
- Trigger DVL with TTL Signal
- 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 DVL.
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 a TRDI transducer. Detailed drawings of TRDI's transducers are available upon request from TRDI.

Figure 69 shows a side view of a transducer and sea chest, and Figure 70 shows the sea chest in more detail. Figure 71 and Figure 72 shows an alternate sea chest/gate valve installation. Figure 73 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 DVL, 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 DVL 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 DVL. 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 15° 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, than the alignment holes will ensure that the transducer also aligns within 0.05° 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 DVL 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, than 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, than 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 than the seal is acceptable. If the well is filled with air than 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, than air will not properly bleed from the well and DVL 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 than 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, than it must be unclogged. This procedure should be repeated periodically to keep the pipe open.

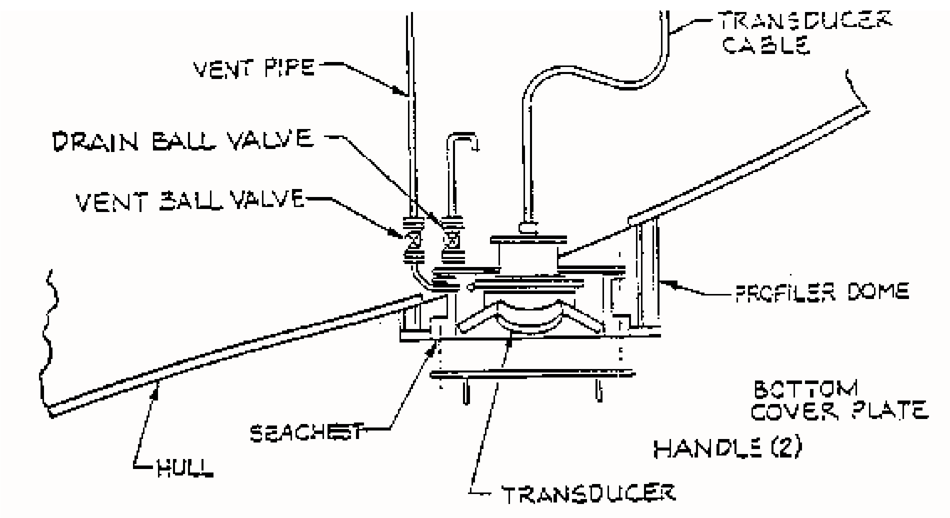

Figure 69. Side View of Transducer and Sea Chest in a Sloping Hull

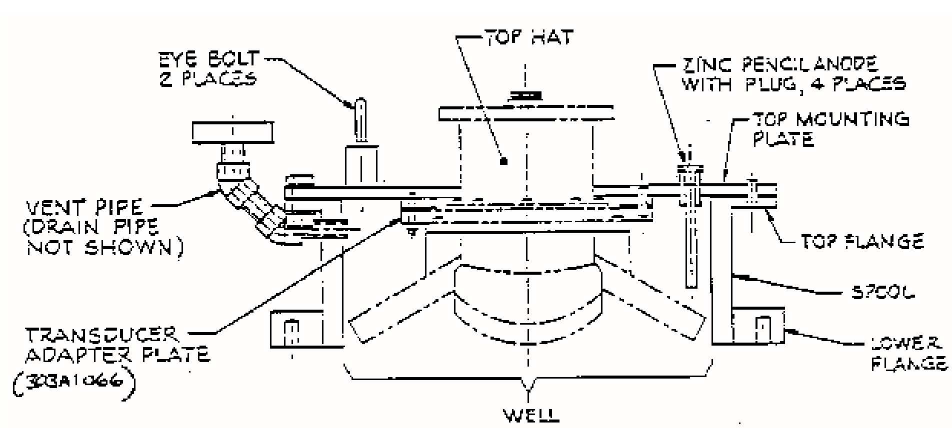

Figure 70. Expanded View of a Sea Chest

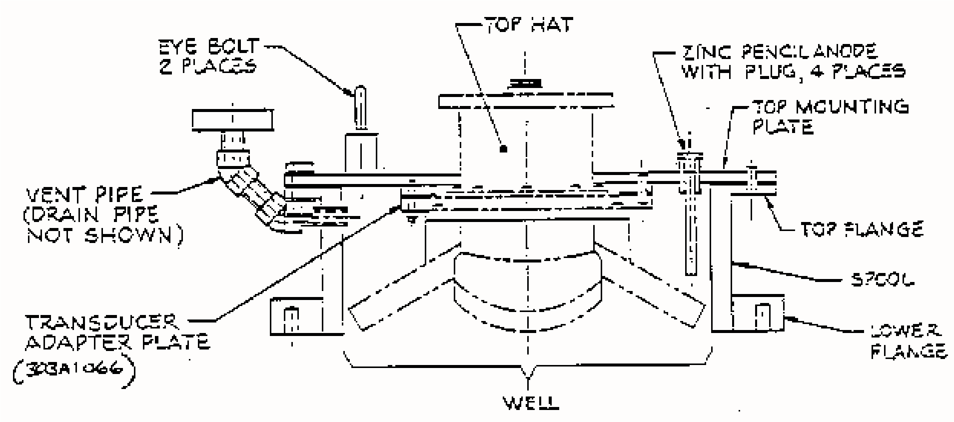

Figure 71. Stemmed Transducer using a Three Inch Gate Valve

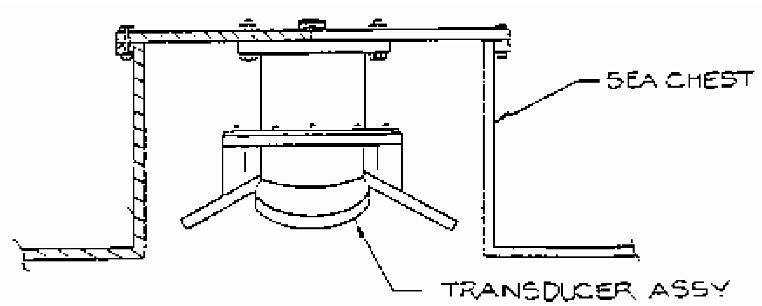

Figure 72. Transducer Without Stem

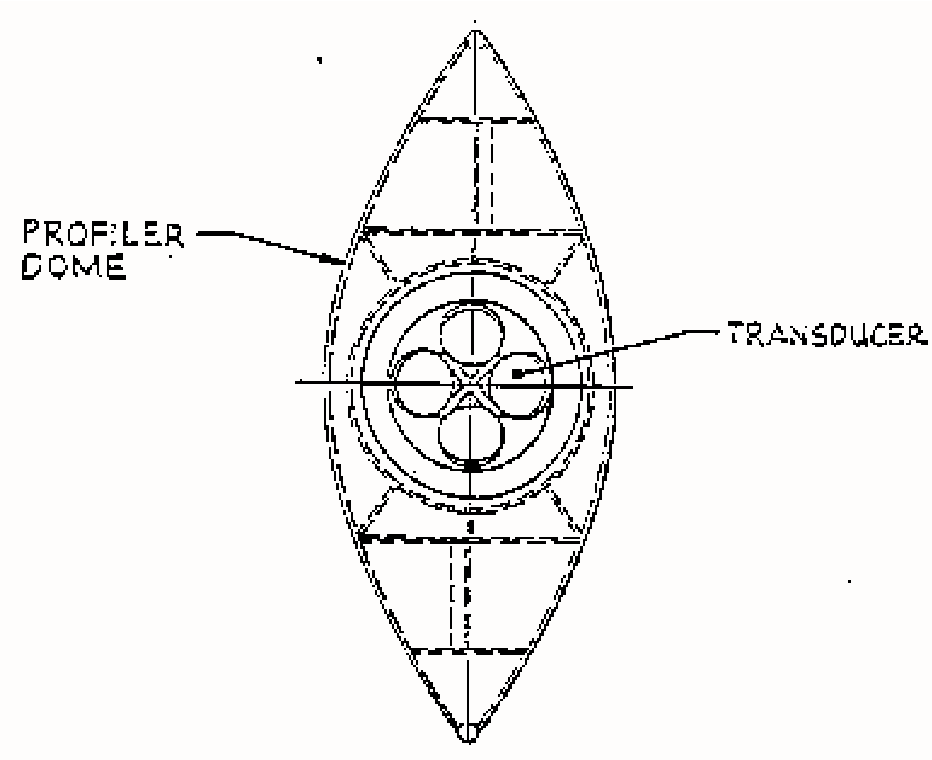

Figure 73. Profiler Dome

FSA-007 - Effect of a Moving Bottom Condition:

In High Flow (Flood) or High Sediment Concentration Conditions

Conditions Characterized by:	Not Characterized by:
• Unstable (Moving) Bottom	• Stable Bottom
• High Suspended Sediment Near River Bed	• Unbiased Bottom Track
• Biased Bottom Track Data	• Valid Bottom Track Depths
• High Water Velocities	

Introduction

The primary function of bottom-track is to measure the DVL'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 DVL,
- 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 DVL 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 DVL will not detect the true range to the bottom.

Some users have gotten around this problem by using a lower frequency DVL. 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 DVL, *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%

The DVL 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 74, 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.

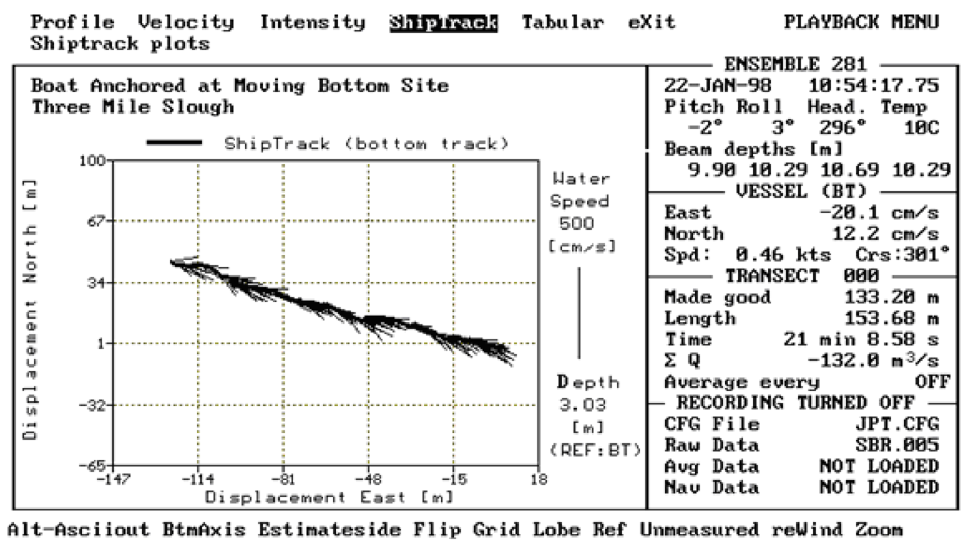

Figure 74. Ship's Track showing Bottom Track Bias

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 DVL cannot measure water profiles due to very high levels of absorption. A schematic of the environmental conditions is shown Figure 75.

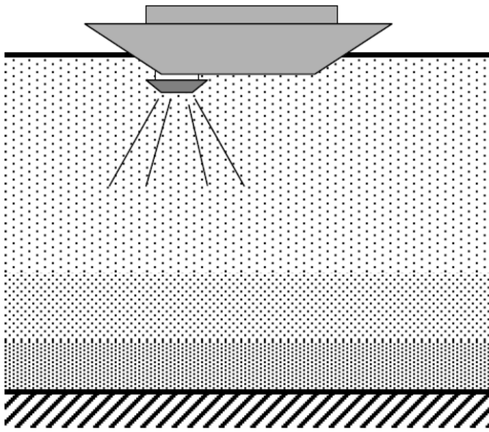

Figure 75. High Flow & Sediment Concentration Effects on Water Profiling & Bottom Tracking

Environmental Sources of Biased Bottom Track Velocities

There are two environmental sources that can produce biased values for DVL bottom track velocities.

1. 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.

2. 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 DVL 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, than 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, than 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 feedback 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 71: 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 72: 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. 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, 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.

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) 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 76. 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? for more information).

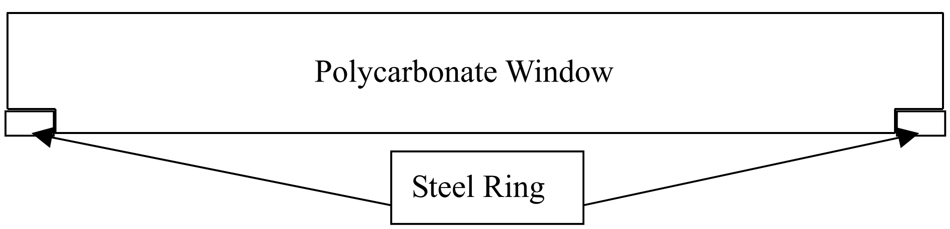

Figure 76. Conceptual Drawing of an Acoustic Window with Mounting Ring

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 77.

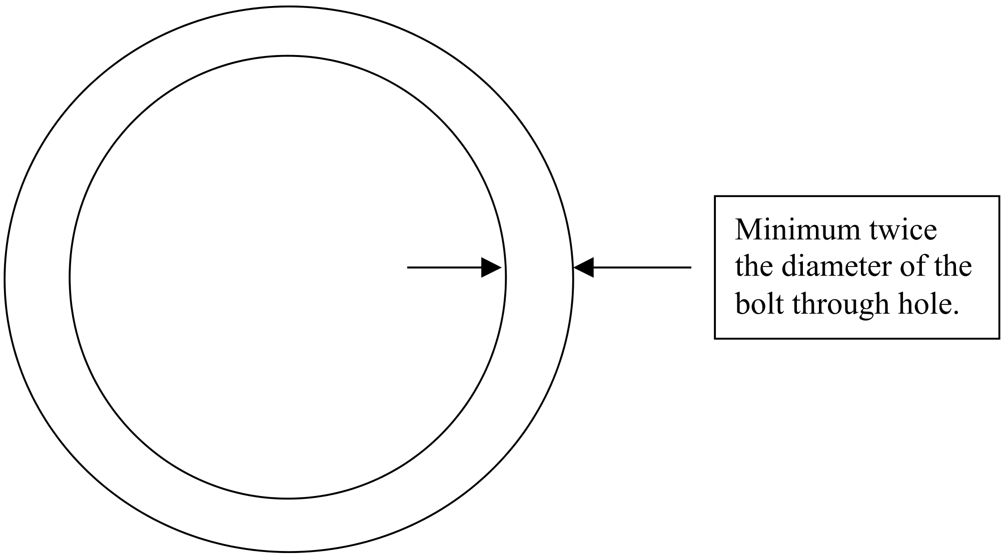

Figure 77. Location of the Window Bolt Hole Circle Diameter

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, than 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, than you must make sure that they are outside of the acoustic beam pattern of the beams, see Figure 78. 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.

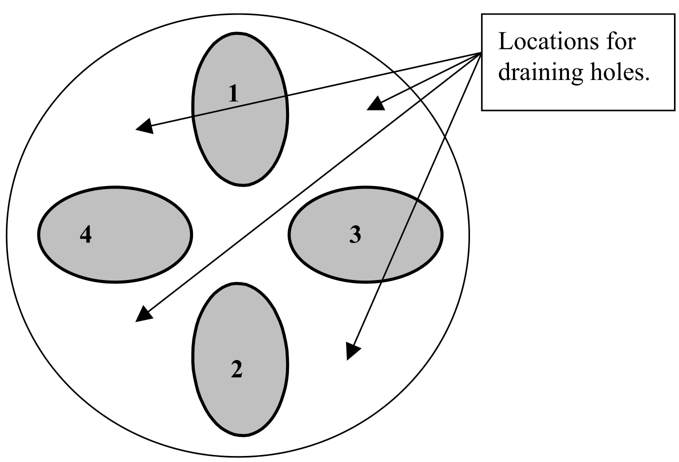

Figure 78. Drain hole locations around beams 1-4 intersection with the window.

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 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, than 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, than 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 73: 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, than this air will not fill the sea chest. However, if the window is not sealed than 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, than 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 71 and Table 72 of this document.

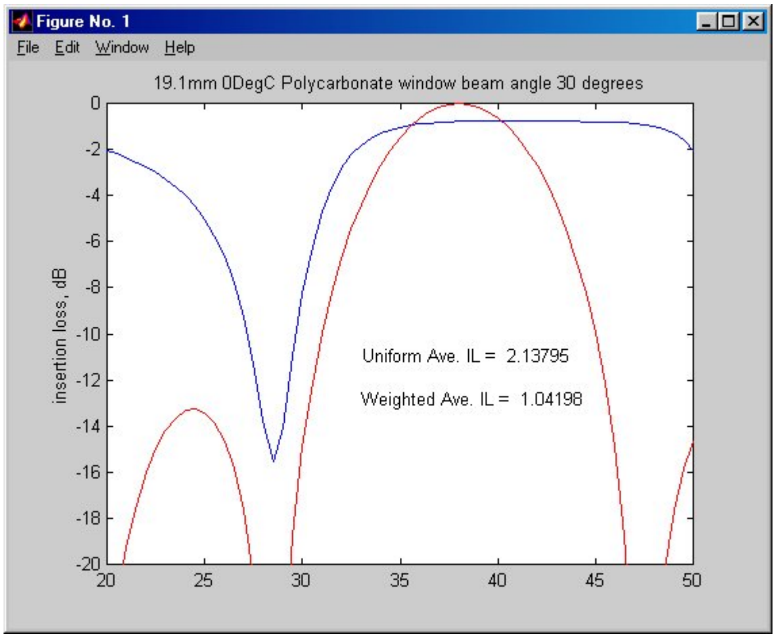

Figure 79. 38 kHz Insertion Loss (one-way) with a 19.1mm window at 0°C

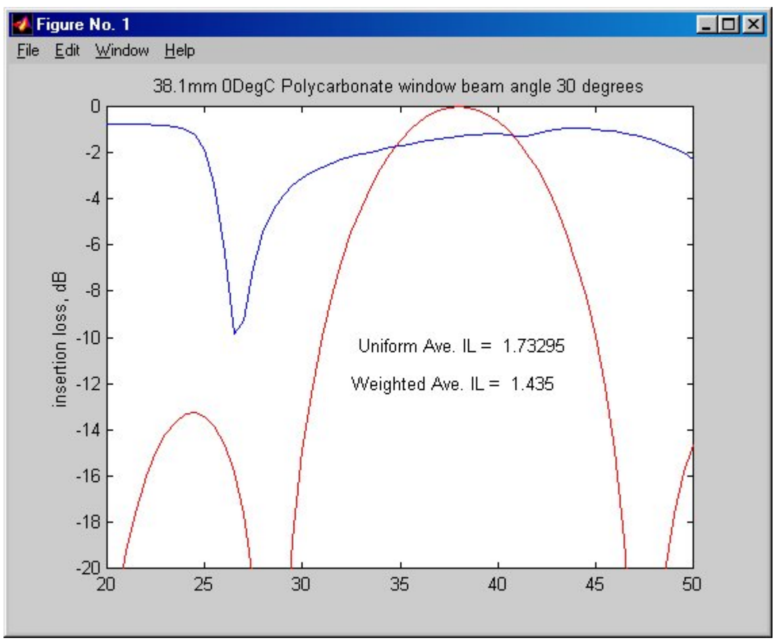

Figure 80. 38 kHz Insertion Loss (one-way) with a 38.1mm window at 0°C

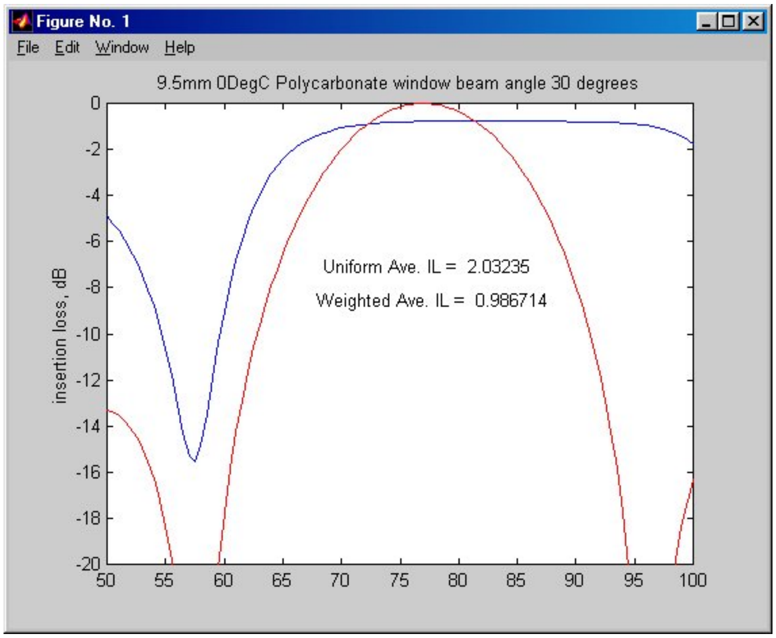

Figure 81. 75 kHz Insertion Loss (one-way) with a 9.5mm window at 0°C

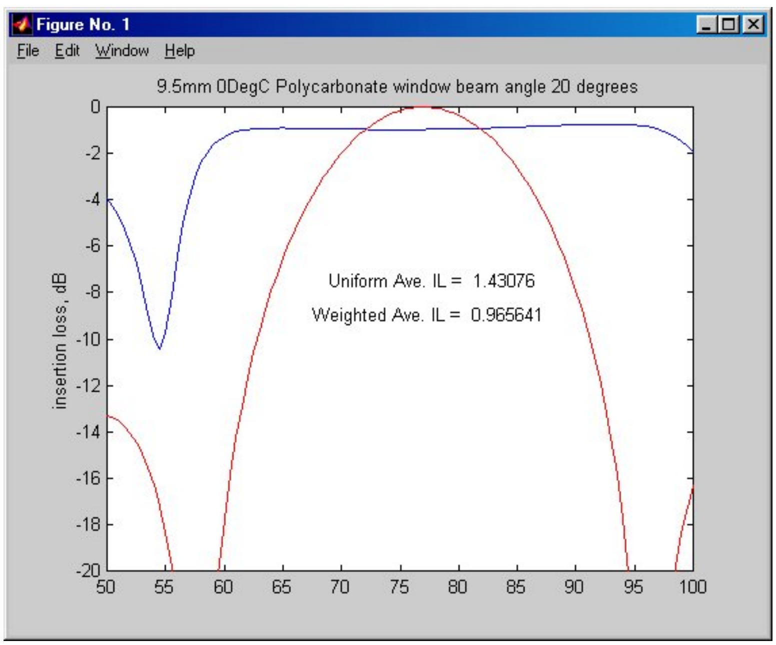

Figure 82. 75 kHz Insertion Loss (one-way) with a 9.5mm window at 0°C

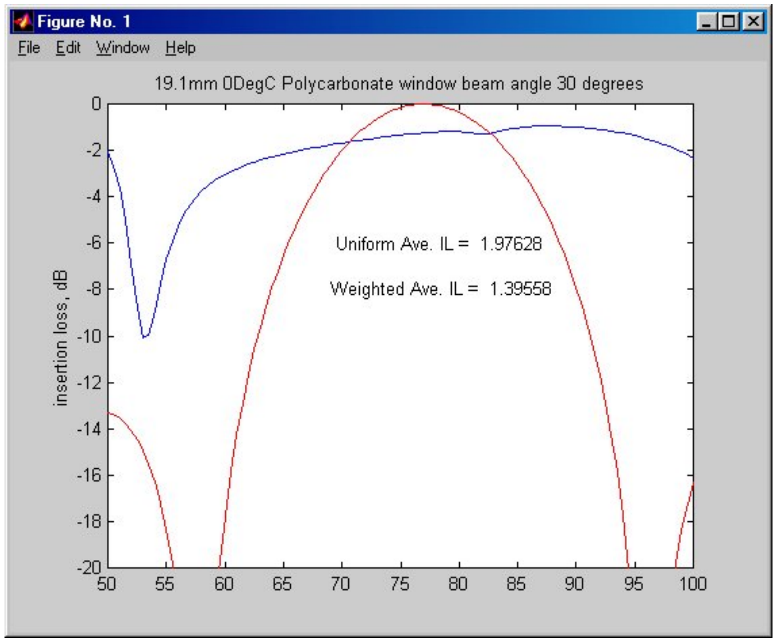

Figure 83. 75 kHz Insertion Loss (one-way) with a 19.1mm window at 0°C

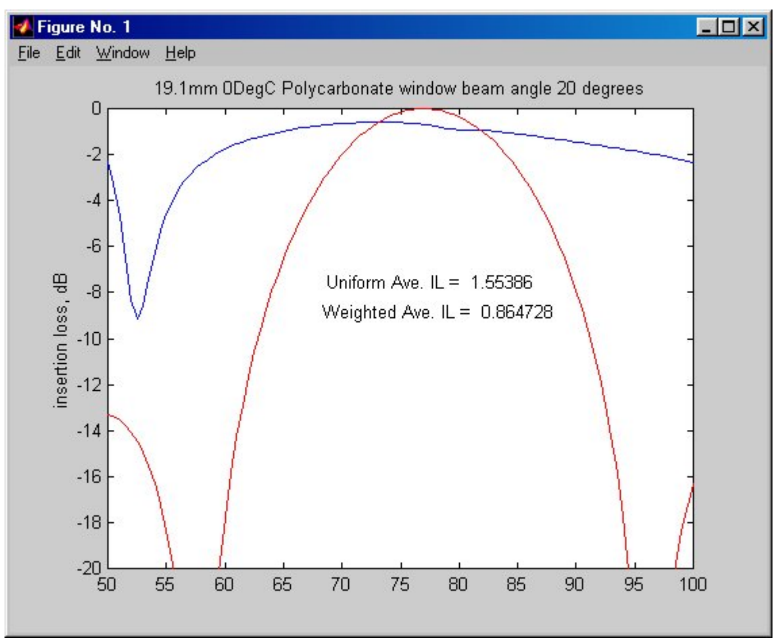

Figure 84. 75 kHz Insertion Loss (one-way) with a 19.1mm window at 0°C

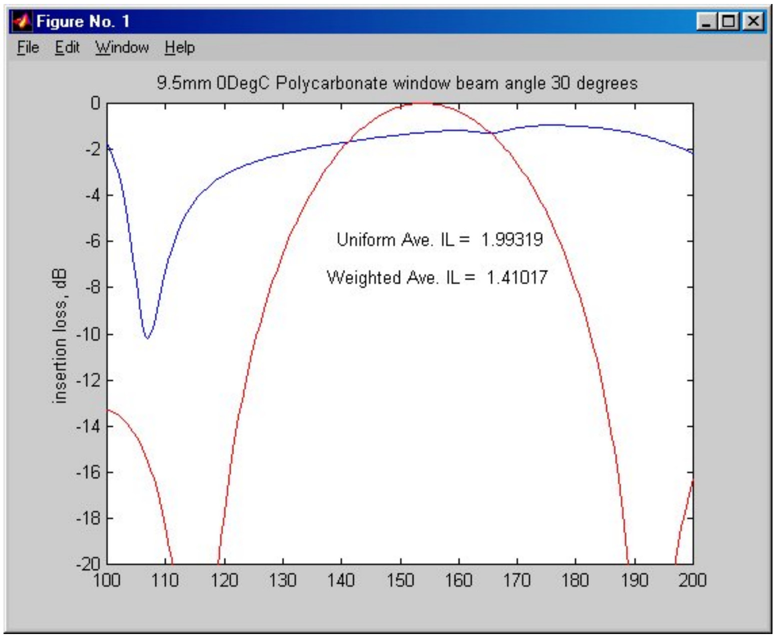

Figure 85. 150 kHz Insertion Loss (one-way) with a 9.5mm window at 0°C

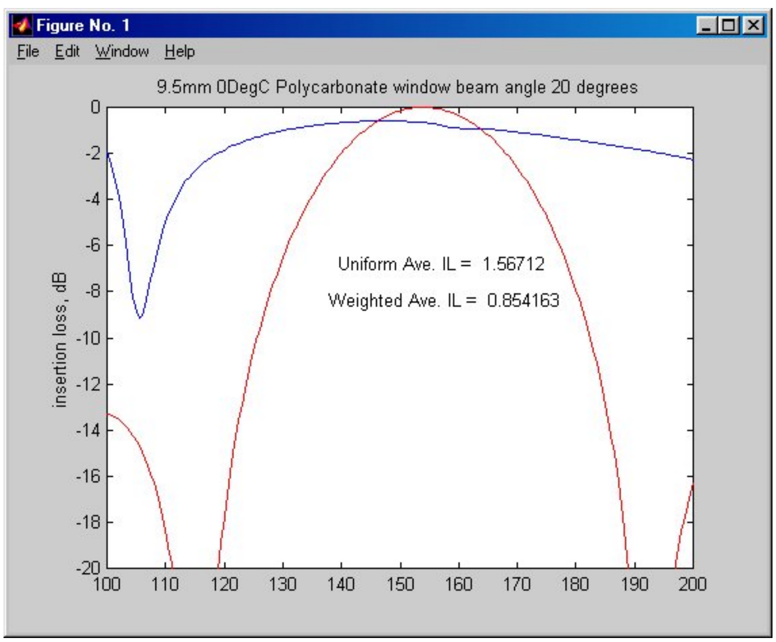

Figure 86. 150 kHz Insertion Loss (one-way) with a 9.5mm window at 0°C

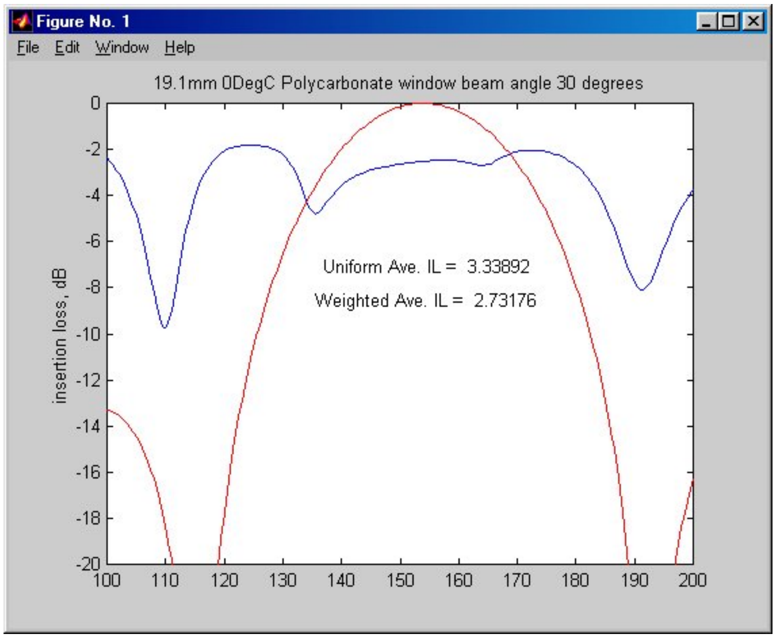

Figure 87. 150 kHz Insertion Loss (one-way) with a 19.1mm window at 0°C

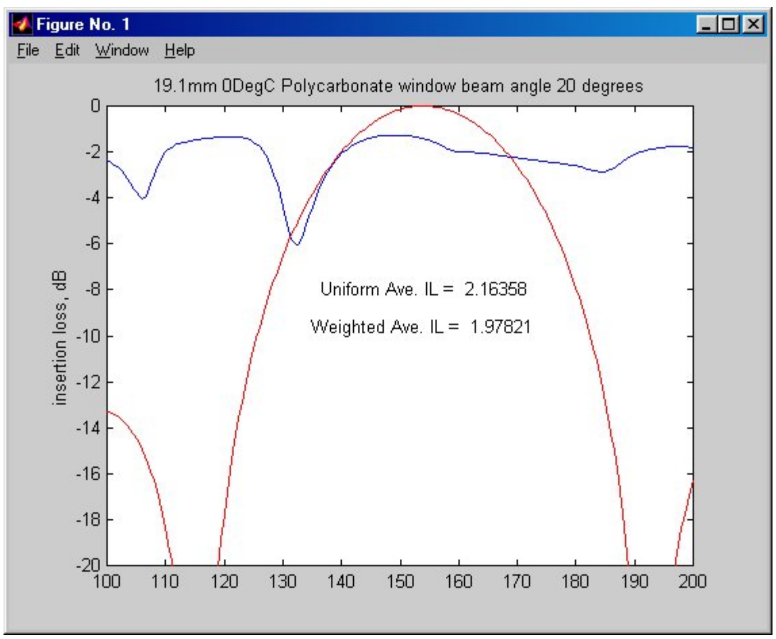

Figure 88. 150 kHz Insertion Loss (one-way) with a 19.1mm window at 0°C

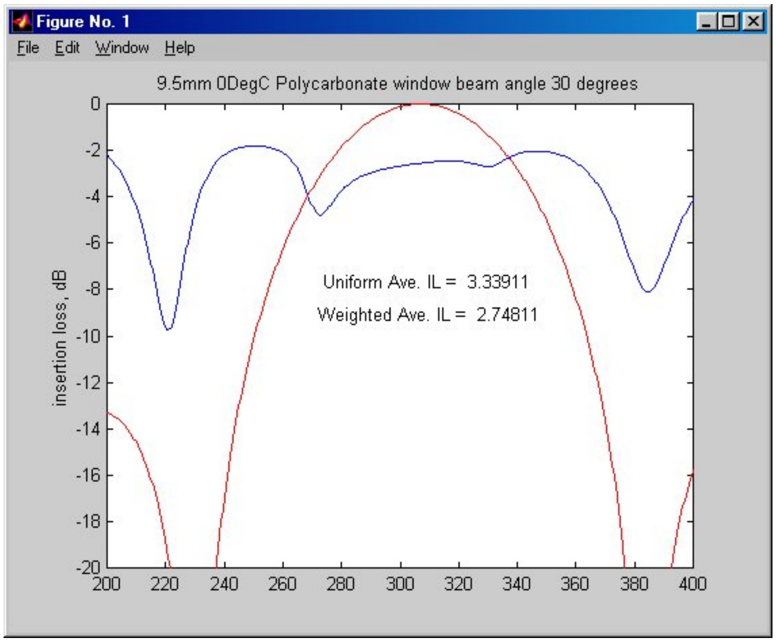

Figure 89. 300 kHz Insertion Loss (one-way) with a 9.5mm window at 0°C

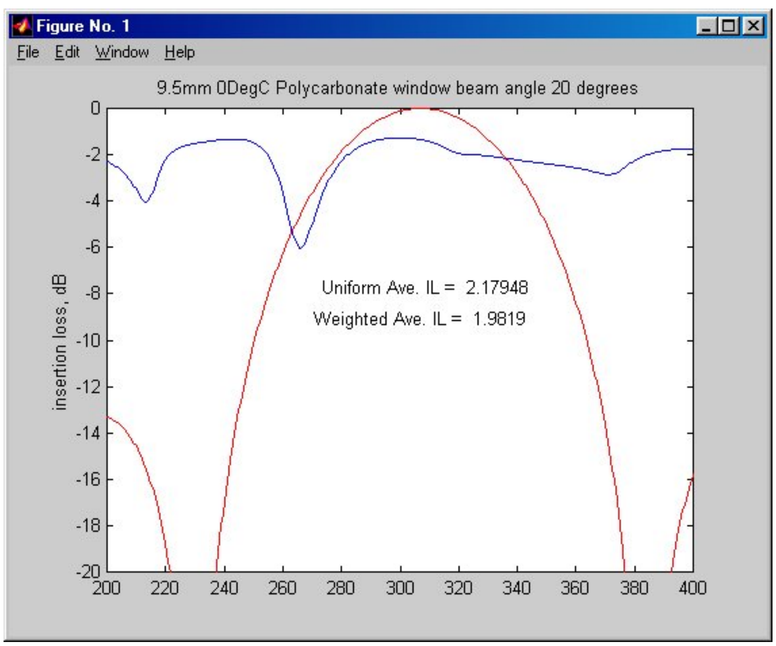

Figure 90. 300 kHz Insertion Loss (one-way) with a 9.5mm window at 0°C

Conceptual Transducer Well Design

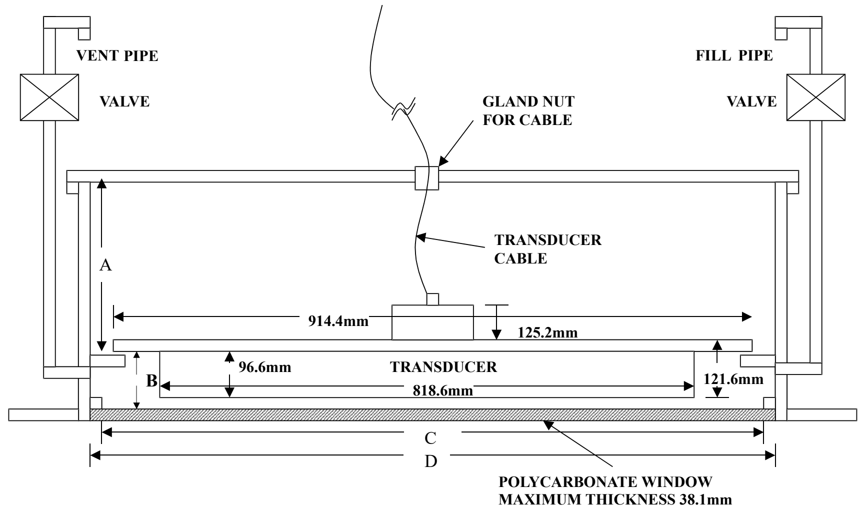

Figure 91. Inside Vessel Mounting - OS 38 kHz Transducer

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:

1. No liability is assumed by Teledyne 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.
2. 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.
3. 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.
4. The listed minimum and maximum dimensions are recommendations based on maintaining the clearance for the transducer as well as providing the smallest well possible.
5. 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.
6. Inserts in the transducer housing mounting holes may be used to provide additional isolation from vessel.
7. 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.
8. 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.
9. Window thickness should not exceed 38.1 mm of Polycarbonate material. Thinner Polycarbonate window is OK.
10. Window faces should be parallel to the transducer face to within 2 degree for best performance; angle should never exceed 5 degrees.

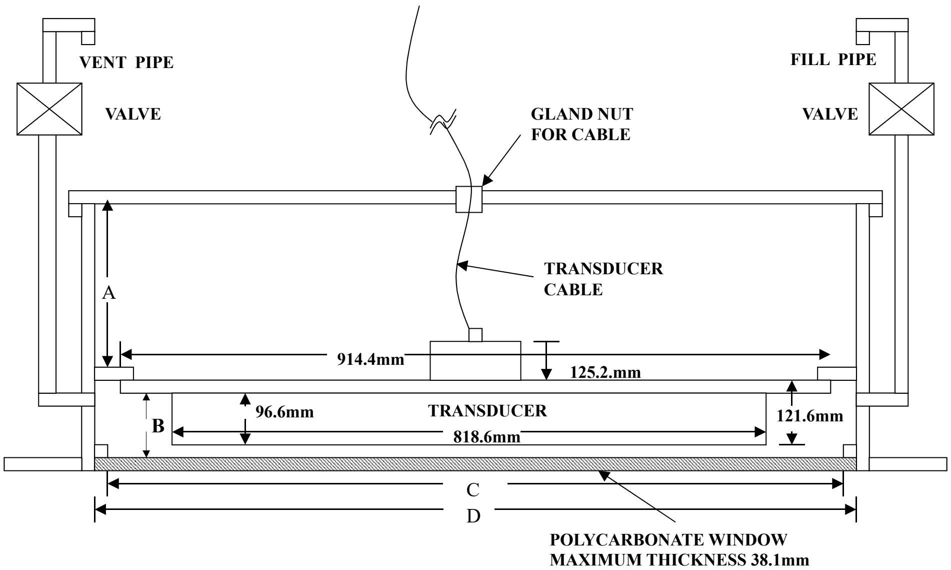

Figure 92. Underneath Vessel Mounting - OS 38 kHz Transducer

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:

1. No liability is assumed by Teledyne 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.
2. 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.
3. This conceptual well drawing is designed such that it would be possible to remove the transducer from beneath the vessel while in dry dock.
4. The listed minimum and maximum dimensions are recommendations based on maintaining the clearance for the transducer as well as providing the smallest well possible.
5. 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.
6. Inserts in the transducer housing mounting holes may be used to provide additional isolation from vessel.
7. 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.
8. 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.
9. Window thickness should not exceed 38.1 mm of Polycarbonate material. Thinner Polycarbonate window is OK.
10. Window faces should be parallel to the transducer face to within 2 degree for best performance; angle should never exceed 5 degrees.

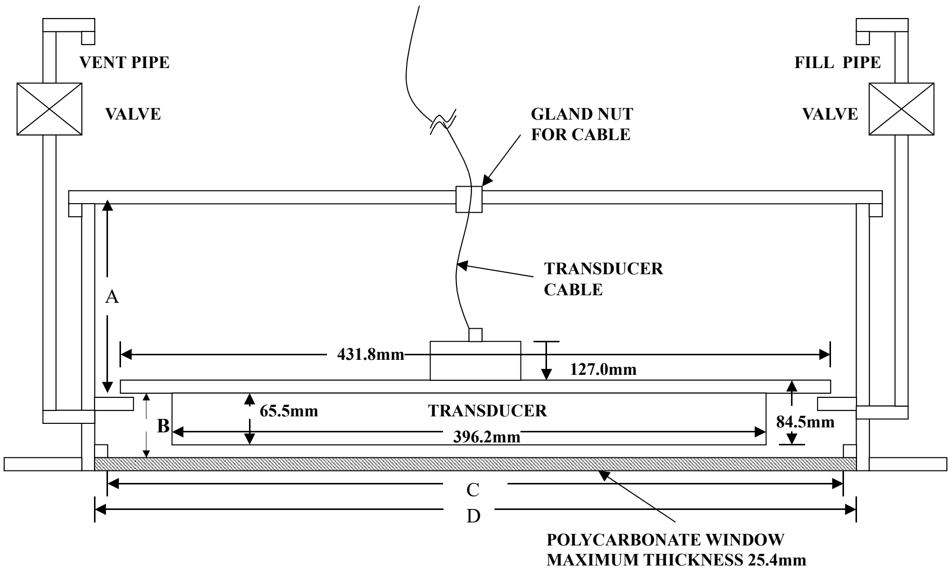

Figure 93. Inside Vessel Mounting - OS 75 kHz Transducer

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:

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2. 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.
3. 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.
4. The listed minimum and maximum dimensions are recommendations based on maintaining the clearance for the transducer as well as providing the smallest well possible.
5. 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.
6. Inserts in the transducer housing mounting holes may be used to provide additional isolation from vessel.
7. 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.
8. 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.
9. Window thickness should not exceed 25.4 mm of Polycarbonate material. Thinner Polycarbonate window is OK.
10. Window faces should be parallel to the transducer face to within 2 degree for best performance; angle should never exceed 5 degrees.

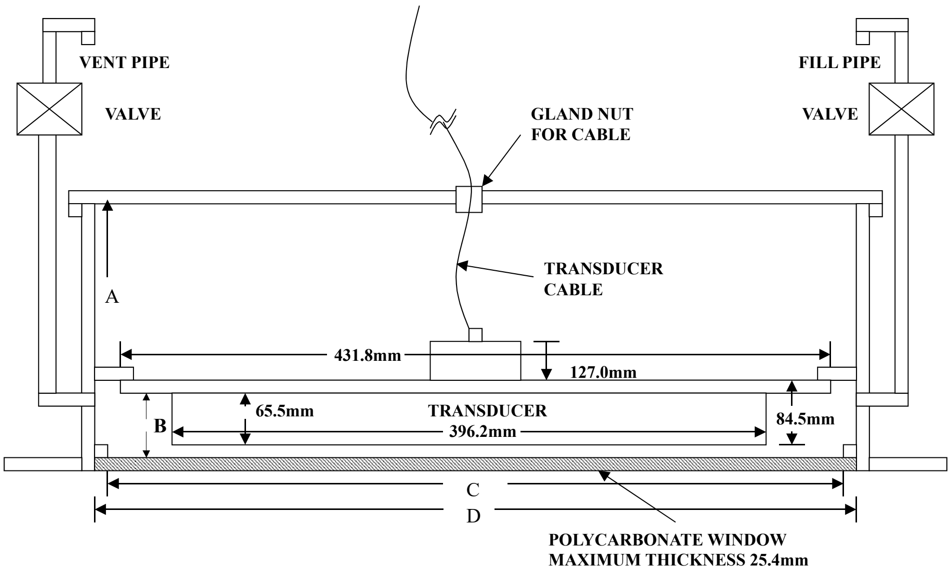

Figure 94. Underneath Vessel Mounting - OS 75 kHz Transducer

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:

1. No liability is assumed by Teledyne 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.
2. 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.
3. This conceptual well drawing is designed such that it would be possible to remove the transducer from beneath the vessel while in dry dock.
4. The listed minimum and maximum dimensions are recommendations based on maintaining the clearance for the transducer as well as providing the smallest well possible.
5. 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.
6. Inserts in the transducer housing mounting holes may be used to provide additional isolation from vessel.
7. 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.
8. 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.
9. Window thickness should not exceed 25.4 mm of Polycarbonate material. Thinner Polycarbonate window is OK.
10. Window faces should be parallel to the transducer face to within 2 degree for best performance; angle should never exceed 5 degrees.

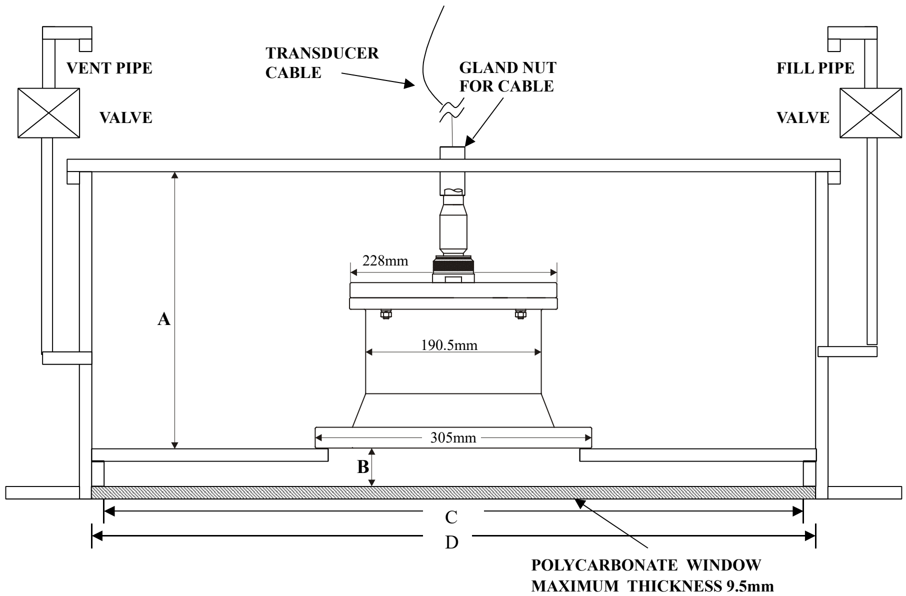

Figure 95. Inside Vessel Mounting - OS 150 kHz Flanged Transducer

Dimension Letter	Option 1 Minimum Dimension	Option 2 Maximum Dimension
A	384mm	738mm
B	6.5mm	13mm
C	255mm	268mm
D	357mm	370mm

***Special Notes*:**

1. No liability is assumed by Teledyne 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.
2. 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.
3. 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.
4. The listed minimum and maximum dimensions are recommendations based on maintaining the clearance for the transducer as well as providing the smallest well possible.
5. 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.
6. Inserts in the transducer housing mounting holes may be used to provide additional isolation from vessel.
7. 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.
8. 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.
9. Window thickness should not exceed 9.5 mm of Polycarbonate material. Thinner Polycarbonate window is OK.
10. Window faces should be parallel to the transducer face to within 2 degree for best performance; angle should never exceed 5 degrees.

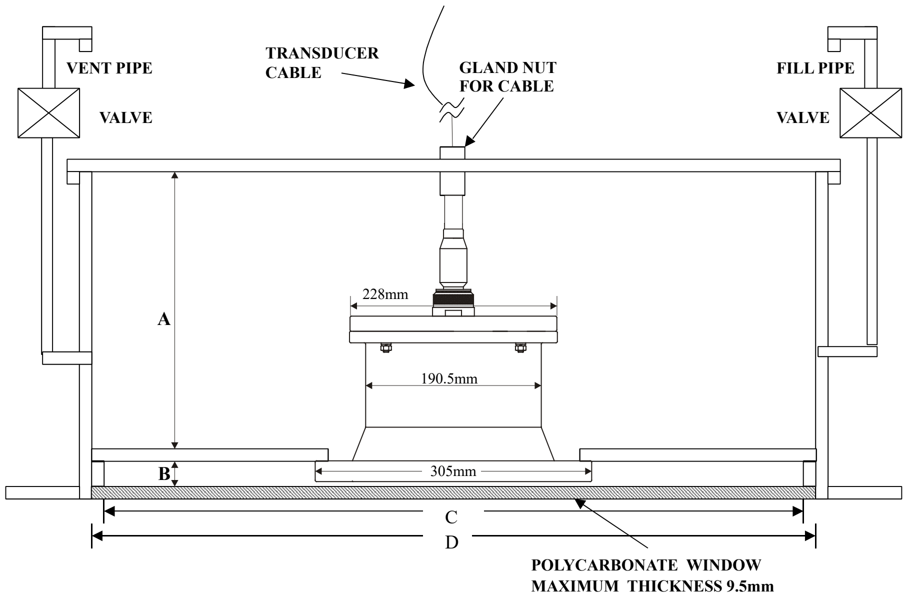

Figure 96. Underneath Vessel Mounting - OS 150 kHz Flanged Transducer

Dimension Letter	Option 1 Minimum Dimension	Option 2 Maximum Dimension
A	361mm	715mm
B	29mm	36mm
C	255mm	268mm
D	357mm	370mm

***Special Notes*:**

1. No liability is assumed by Teledyne 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.
2. 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.
3. This conceptual well drawing is designed such that it would be possible to remove the transducer from beneath the vessel while in dry dock.
4. The listed minimum and maximum dimensions are recommendations based on maintaining the clearance for the transducer as well as providing the smallest well possible.
5. 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.
6. Inserts in the transducer housing mounting holes may be used to provide additional isolation from vessel.
7. 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.
8. 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.
9. Window thickness should not exceed 9.5 mm of Polycarbonate material. Thinner Polycarbonate window is OK.
10. Window faces should be parallel to the transducer face to within 2 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 Band-widths than the standard bottom tracking.

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.

Set Up

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:

$$Uab = \frac{1500m/s}{Ns \cdot CPE \cdot EL}$$

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:

$$EL(CPE, Uab) \le \frac{1500m/s}{4 \cdot CPE \cdot Uab}$$

Finishing the example for 12.5% and 6.25% Bandwidths, the appropriate code lengths are

$$EL(8,2.828) \le \frac{1500m/s}{4 \cdot 8 \cdot 2.828m.s} \le 16.575$$

$$EL(16,2.828) \le \frac{1500m/s}{4 \cdot 16 \cdot 2.828} \le 8.288.$$

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 set up 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.

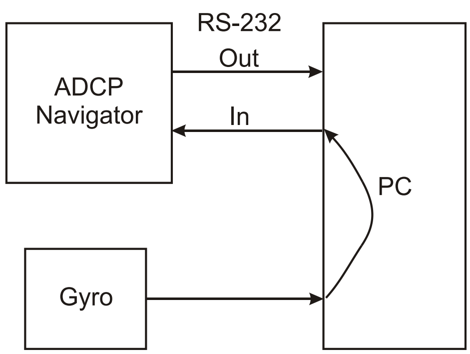

Figure 97. NMEA Heading String Setup

Set Up

1. Set the EZ command to EZxx3xxxx (where x = 1 or 0) to use the NMEA heading rather than the Navigator's internal heading sensor.
2. Start the Navigator pinging.
3. 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.
4. 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.

> 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 74: 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

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.

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.

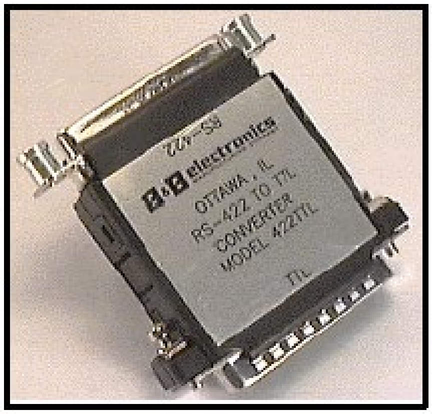

Figure 98. RS-422 to TTL Converter

Set Up

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.

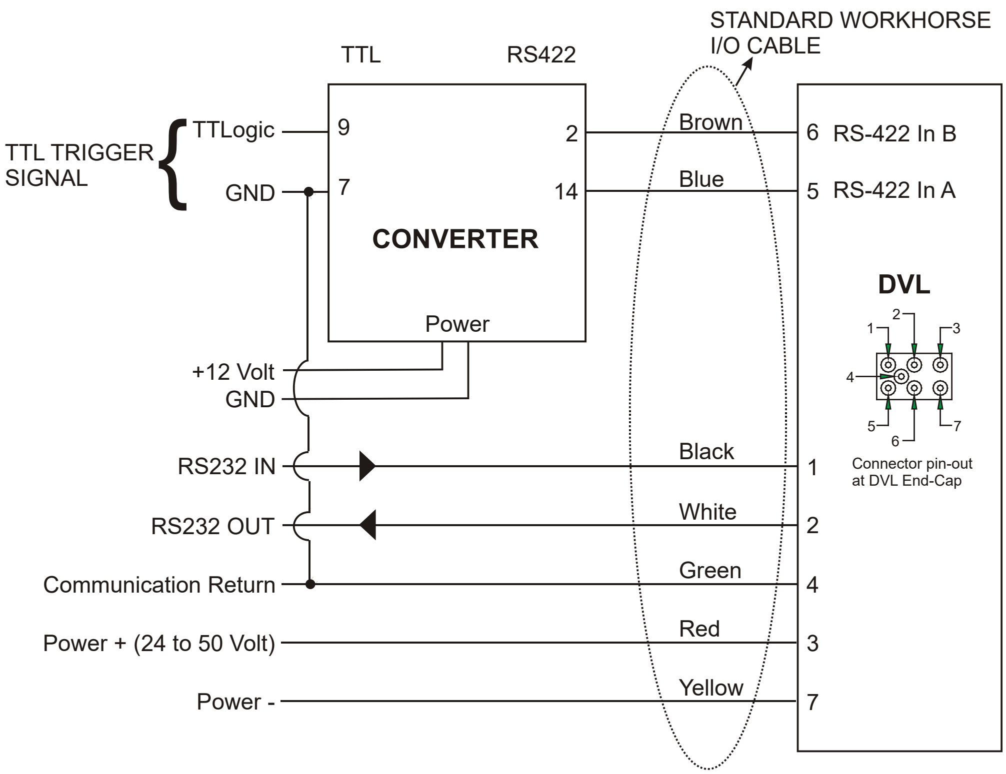

Figure 99. Triggering a DVL with a TTL Signal

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.

In order for the Low Latency Trigger Enable to work, the CL command should be set to CL0. Using CL1 may provide unpredictable results.

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.

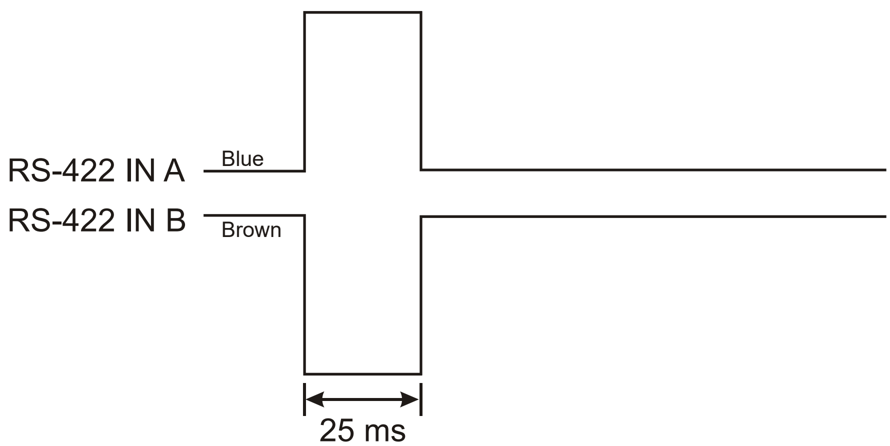

Figure 100. Timing Pulse

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:

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.

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 75: 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

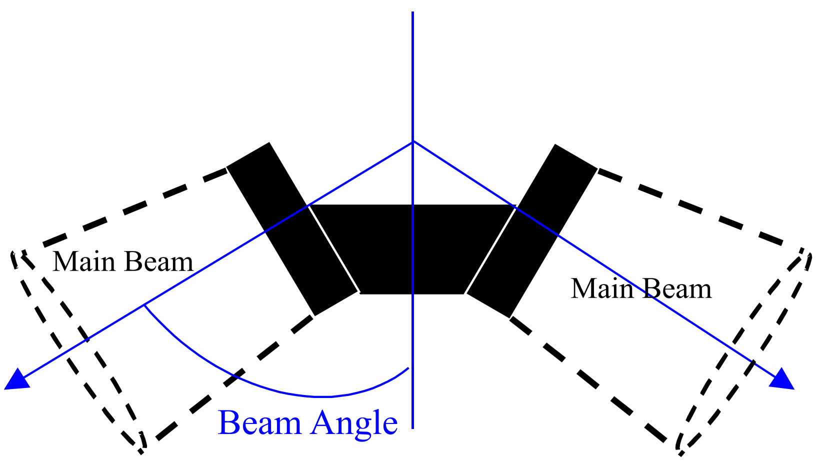

Figure 101. Beam Angle & Pattern with Four Individual Beam Transducer

Only two beams are shown. The second pair of beams are at right angles to this pair.

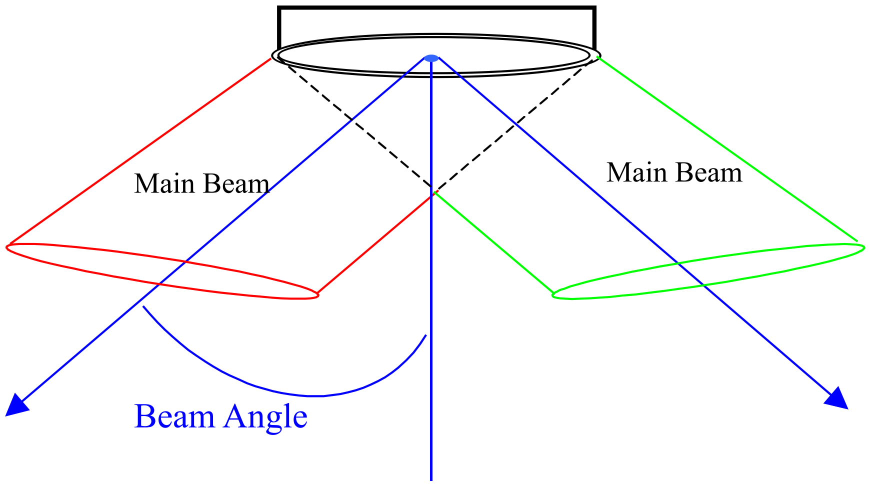

Figure 102. Beam Angle & Pattern with the OS/OO ADCP Phased Array Transducer

Only two beams are shown. The second pair of beams are at right angles to this pair.

Table 76: 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

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 101) or if the beam is created by the phased array transducer (as in Figure 102).

Figure 103 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.

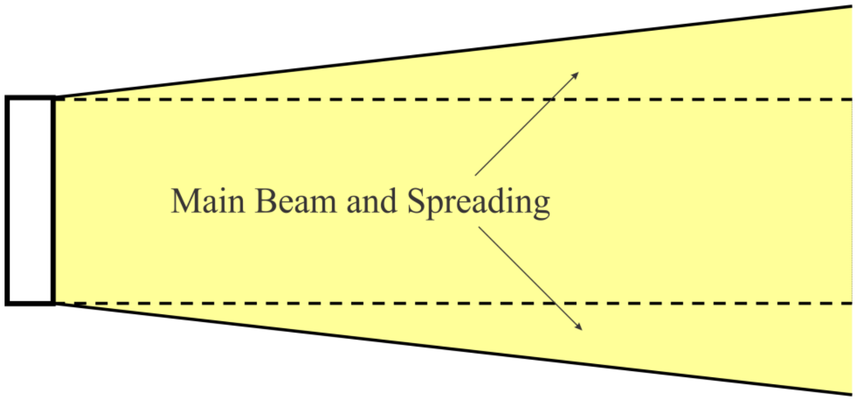

Figure 103. View of Main Beam Spreading

Figure 104 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).

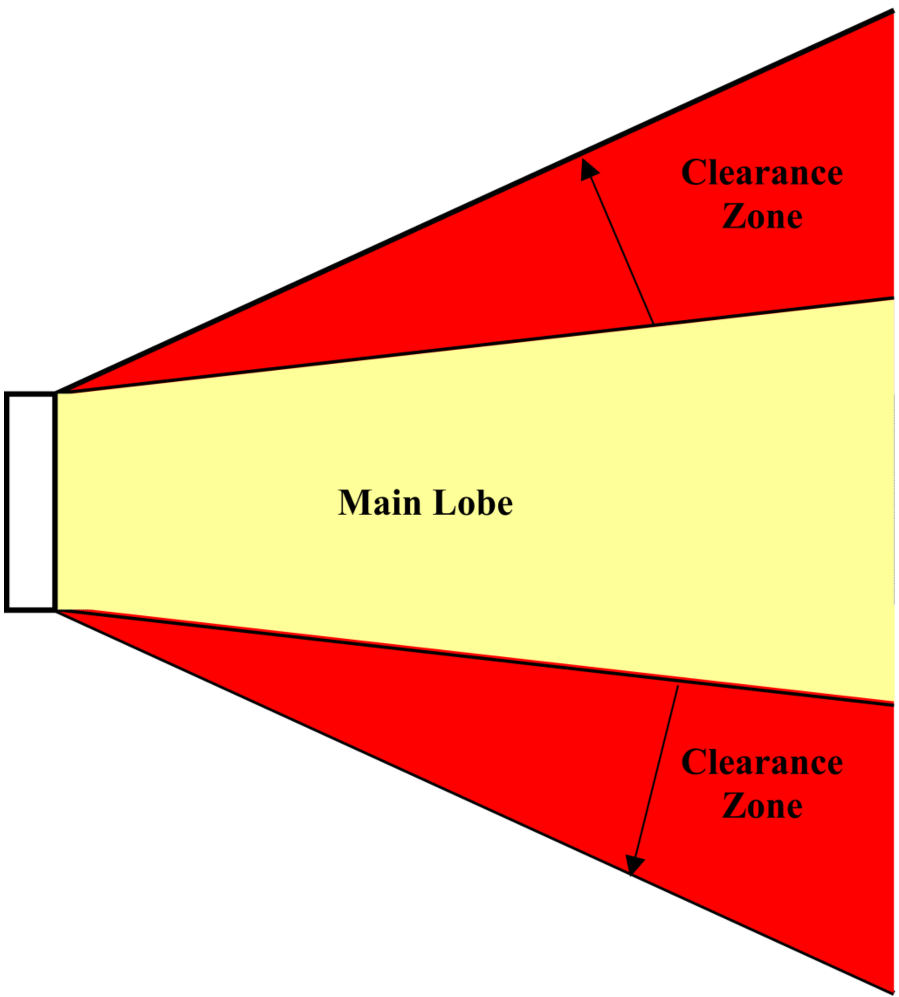

Figure 104. View of Clearance Zone Width

In Figure 103 and Figure 104 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.

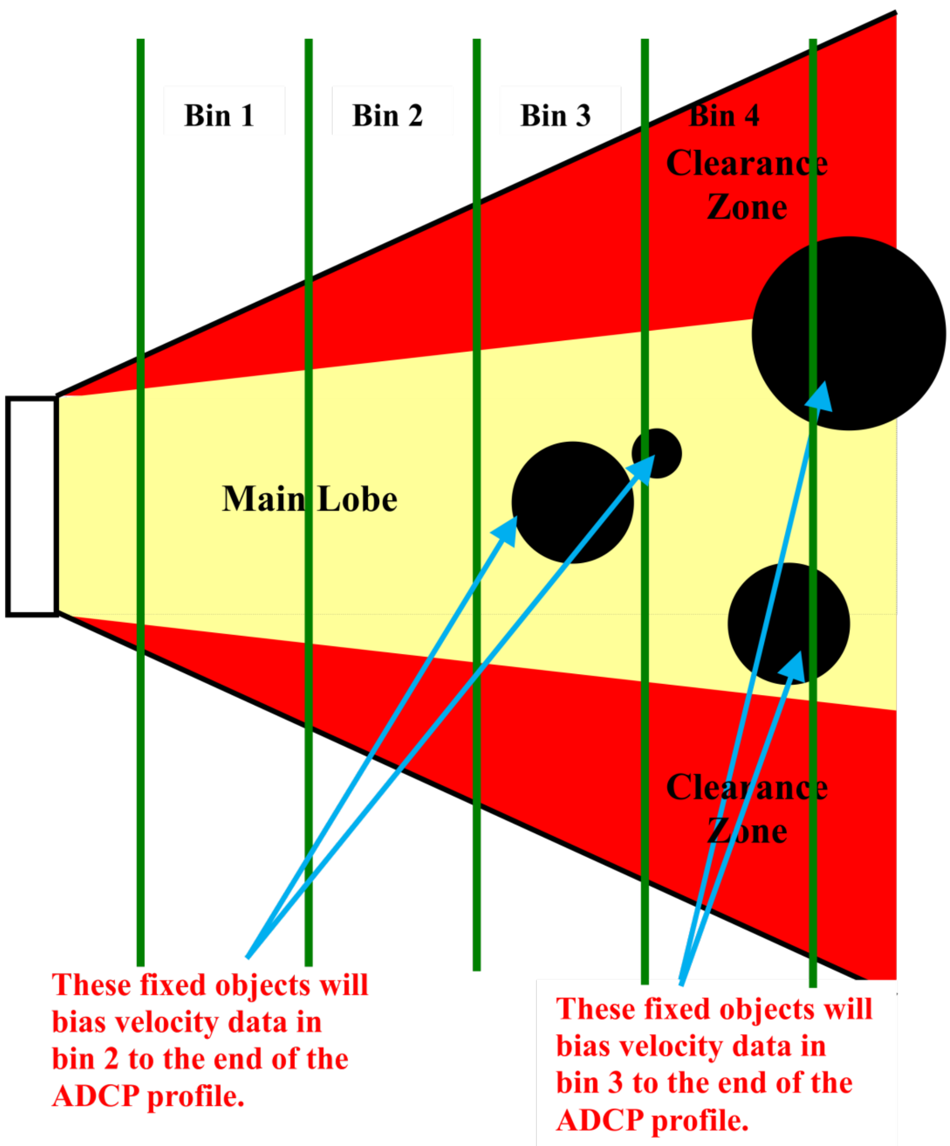

Figure 105. Profile Bias Caused by Objects in the Main Beam

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 106 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.

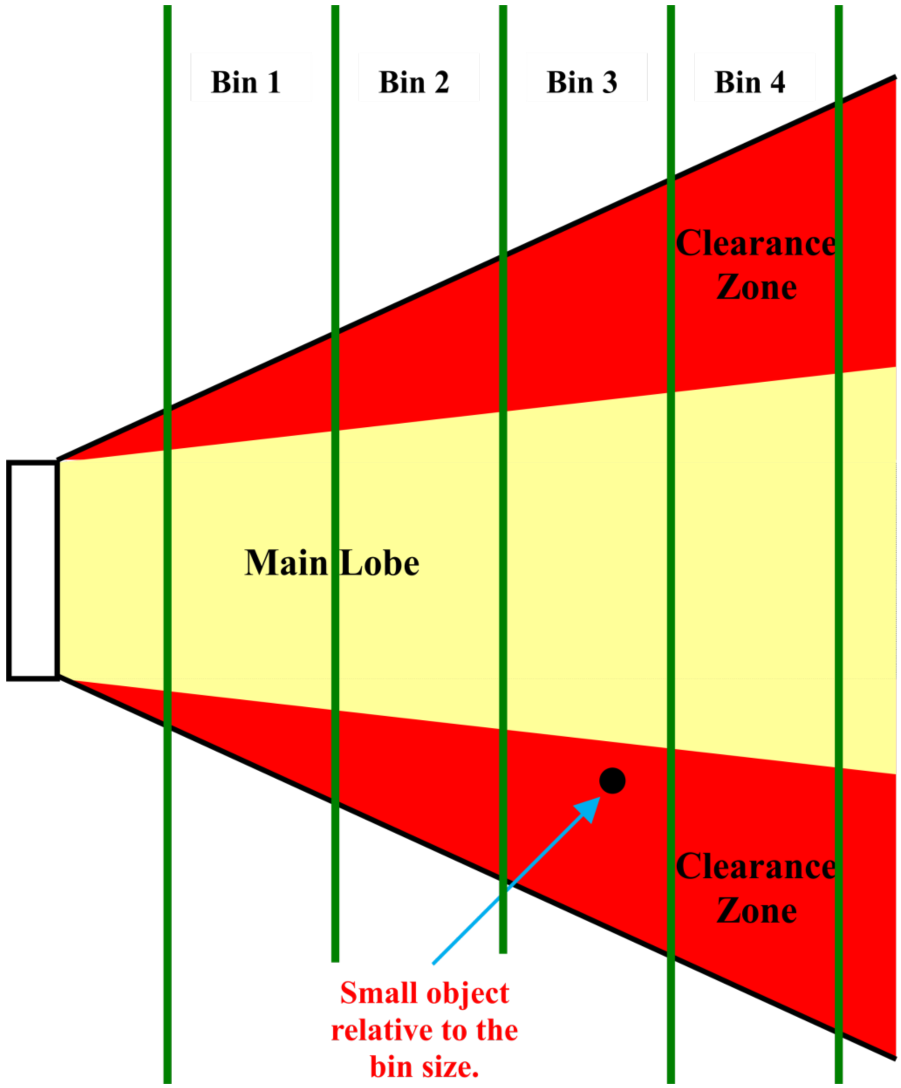

Figure 106. Small Object Biasing a Single Bin and the Adjoining Bins

In Figure 107 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.

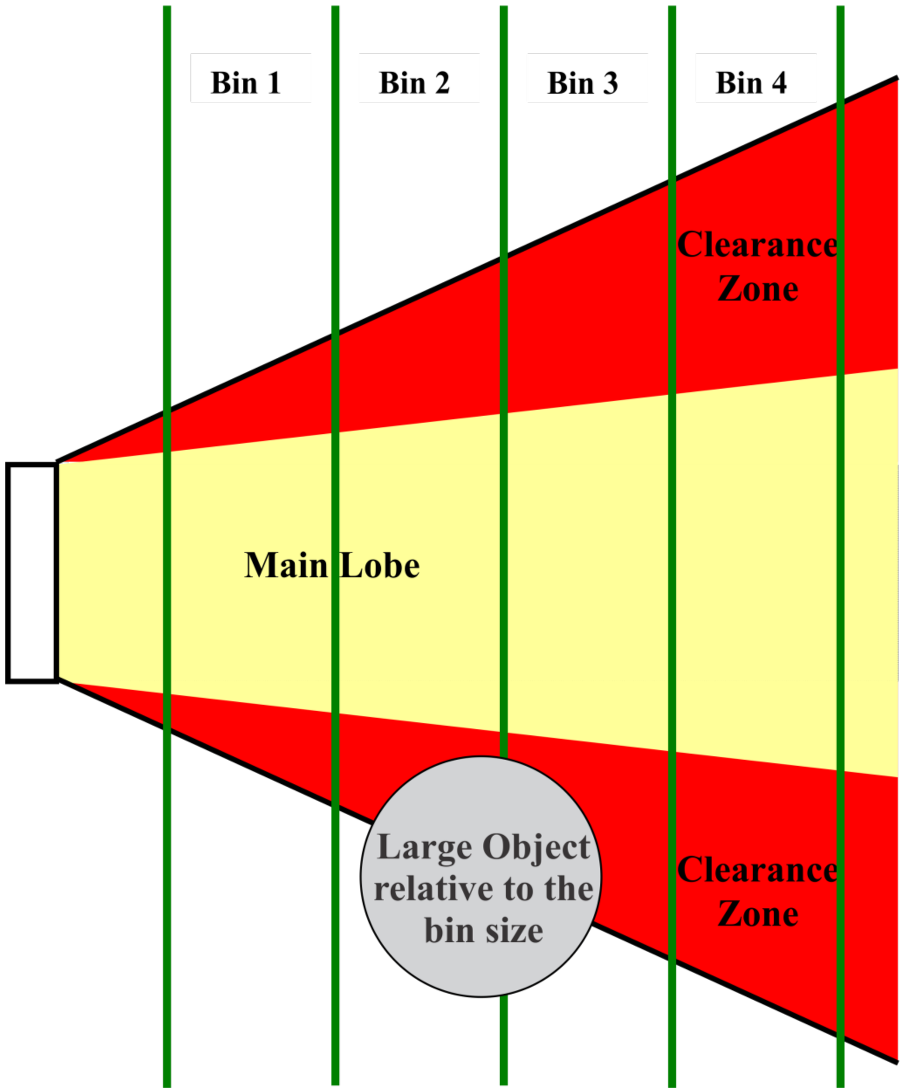

Figure 107. Large Object Biasing Two Bins and the Adjoining Bins

Notes

Appendix B

NOTICE OF COMPLIANCE

In this chapter, you will learn:

- China RoHS requirements
- Material disclosure table

Notice of Compliance

Date of Manufacture

China RoHS requires that all Electrical and Electronic Products are marked with a Date of Manufacture. This is the starting point for the Environmental Friendly Use Period, described below.

Environmental Friendly Use Period (EFUP)

Per SJ/T 11364-2006 – Product Marking, the EFUP is defined as the time in years in which hazardous/toxic substances within Electrical and Electronic Products (EIP) will not, under normal operating conditions, leak out of the Product, or the Product will not change in such a way as to cause severe environmental pollution, injury to health, or great damage to property. TRDI has determined the Environmental Friendly Use Period shall be Ten (10) years.

The purpose of the marking is to assist in determining the restricted substance content, recyclability, and environmental protection use period of our covered products, as required in Chinese law, and does not reflect in any way the safety, quality, or warranty associated with these TRDI products.

Some homogenous substance within the EIP contains toxic or hazardous substances or elements above the requirements listed in SJ/T 11363-2006. These substances are identified in Table 77.

WEEE

The mark shown to the left is in compliance with the Waste Electrical and Electronic Equipment Directive 2002/96/EC (WEEE).

This symbol indicates the requirement NOT to dispose the equipment as unsorted municipal waste, but use the return and collection systems according to local law or return to one of the TRDI facilities below.

Teledyne RD Instruments USA
14020 Stowe Drive
Poway, California 92064

Teledyne RD Instruments Europe
2A Les Nertieres
5 Avenue Hector Pintus
06610 La Gaude, France

Teledyne RD Technologies
1206 Holiday Inn Business Building
899 Dongfang Road, Pu Dong
Shanghai 20122
China

CE

This product complies with the Electromagnetic Compatibility Directive 89/336/EEC, 92/31/EEC. The following Standards were used to verify compliance with the directives: EN 61326(1997), A1(1998), A2(2001) – Class "A" Radiated Emissions.

Material Disclosure Table

In accordance with SJ/T 11364-2006, the following table disclosing toxic or hazardous substances contained in the product is provided.

Table 77: Toxic or Hazardous Substances and Elements Contained in Product

零件项目(名称) Component Name	有毒有害物质或元素 Toxic or Hazardous Substances and Elements					
	铅 Lead (Pb)	汞 Mercury (Hg)	镉 Cadmium (Cd)	六价铬 Hexavalent Chromium (Cr^{6+})	多溴联苯 Polybrominated Biphenyls (PBB)	多溴二苯醚 Polybrominated Diphenyl Ethers (PBDE)
换能器配件 Transducer Assy.	X	O	O	O	O	O
接收机电路板 Receiver PCB	X	O	O	O	O	O
数据处理器电路板 DSP PCB	X	O	O	O	O	O
微处理器电路板 CPU PCB	X	O	O	O	O	O
输入输出口电路板 PIO PCB	X	O	O	O	O	O
机体装配 Housing Assy.	X	O	O	O	O	O
底座装配 End-Cap Assy.	X	O	O	O	O	O
交流电转换器 AC Voltage Adapter	X	O	O	O	O	O
水下专用电缆 Underwater Cable	X	O	O	O	O	O
专用装运箱和泡沫塑料垫 Shipping Case w/Foam	O	O	O	O	O	O

O: 表示该有毒或有害物质在该部件所有均质材料中的含量均在 SJ/T 11363-2006 标准规定的限量要求以下。
O: Indicates that the toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit required in SJ/T 11363-2006.
X: 表示该有毒或有害物质至少在该部件的某一均质材料中的含量超出 SJ/T 11363-2006 标准规定的限量要求。
X: Indicates that the toxic or hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement in SJ/T 11363-2006.

Notes