

PATHFINDER

DOPPLER VELOCITY LOG (DVL) 600 kHz



P/N 95B-6116-00 (April 2020)

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REVISION HISTORY

April 2020

- Updated the Recommended Practices for Window Use section.
- Updated connector lubrication instructions.
- Corrected O-rings in Kit, Accessories, OEM Pathfinder, Table 18. Removed the 2-037 O-Ring.
- Updated the PT5 command.
- Change TIME-OF-VALIDITY to Time of Validity so it will show up in a search.
- Added updating firmware using the Ethernet port.
- Added NavUI software to the Navigation CD.

September 2019

- Added Supported Sensors section to Chapter 1.
- Added INS integration to Chapter 2.
- Updated electrical integration section.
- Added the OI command to the manual.
- Updated the CT command.
- Updated note on PC2 and PC20 to: This test can be run on the bench, on deck, or in water.
- Updated PC5 and PC50 voltage levels
- Updated the WB command.
- Added installing firmware and feature upgrades to Chapter 4.
- Updated Identifying EMI section FFT plots.
- Corrected value in Table 13 Approximate Bottom Track Ping Times (in milliseconds) and added equation.
- Moved Matlab Output Variable Definitions to Appendix B.
- Added note to Choosing an Output Data Format: The Bottom-Track High Resolution Velocity (5803h) and Navigation Parameters Data (2013h) blocks provide aid in the velocity measurement resolution and quality information for use in an Extended Kalman Filter (EKF) Inertial Navigation System (INS) solution.
- Added Time to Bottom and Time-of-Validity figures.
- Updated Network Configuration Page screen captures to show PD11 and PD26.
- Added PD11 and PD26 output data formats.
- Fixed Table 36 correlation magnitude data identification word. The MSB is 02h, not 20h.
- Fixed Table 37 echo intensity data identification word. The MSB is 03h, not 30h.
- Corrected the Bottom Track Commands output format.

- Updated outline installation drawing 96B-9040.
- Updated the logo to Teledyne Marine.

October 2018

- Updated the specifications for maximum altitude Bottom Track with the optional extended range.
- Updated the OL command with Extended Range Tracking (XRT) mode.
- Updated the BX command default with/without Extended Range Tracking (XRT) mode.
- Updated Figure 29, PDo Standard Output Data Buffer Format.
- Updated Table 31, Summary of Output Data Formats with PDo Speed Over Ground.

June 2018

- Corrected Figure 8. Pathfinder Power/Comm Cable 73B-6057-005 Optional Test Cable, page 15. Changed white/green wire from pin 5 to pin 3 on Ethernet port.

April 2018

- Updated the inventory tables.
- Updated Figure 7, OEM Pathfinder Connections for Bench Test [73B-6059-00 Cable].
- Added additional pictures to OEM Pathfinder Transducer Connections.
- Added bend radius and connector part number to Figure 10 Pathfinder ROV Power/Comm Cable 73B-6058 Pigtail Cable.
- Updated Using UDP Protocol.
- Added the input trigger voltage is 3.3VDC to 7VDC.
- Added how the leak sensor status can be decoded to PC5 and PC50.
- Updated Figure 29 PDo Standard Output Data Buffer Format.
- Added information on PDo variable leader transmit voltage, current, and impedance.
- Updated the HEM Status byte 67 in the Variable Leader data.
- Updated Bottom Track/Water Track STD Deviation description in Navigation Parameters Data.
- Corrected Bottom Track Command Output Data format.
- Added figures for Environmental Command Parameters Output Format, Bottom Track Command Output Data Format, Bottom Track High Resolution Velocity Output Format, Bottom Track Range Output Data Format, Navigation Parameters Data Format, and Sensor Source for Doppler Processing Output Format.
- Added Export Administration Regulations (EAR) footers.

August 2017

- Corrected wiring diagram for 73B-6058 pigtail cable.
- Updated the OEM transducer cable connections.

June 2017

- Initial Release.

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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

Thank you for purchasing a Teledyne RD Instruments Pathfinder Doppler Velocity Log (DVL). Conventions used in the Pathfinder DVL Guide have been established to help learn how to use the system.

Menu items are printed in bold: **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>), press and hold the first key while pressing the second key. Words printed in italics include program names (*TRDI Toolz*) and file names (*TestWH.rds*).

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

```
Pathfinder
Teledyne RD Instruments (c) 2017
All rights reserved.
Firmware Version: 67.xx
```

>

There are four visual aids to help: Notes, Cautions, Recommended Settings, and References.



This paragraph format indicates additional information that may help 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 Pathfinder).



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



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

NOTES

Chapter 1

AT A GLANCE



In this chapter, you will learn:

- System Overview
- Models and Options
- Computer Considerations
- Power Overview
- Setting up the PathFinder System
- How to connect and disconnect the cables
- Cable wiring diagrams
- Using the Network Configuration Page
- Caring for the PathFinder System

Overview

The Pathfinder transducer assembly contains the connectors with connector protective caps, housing, transducer ceramics, and electronics. The standard acoustic frequency is 600 kHz. See the [Outline Installation Drawings](#) for dimensions and weights.



The urethane face covers the transducer ceramics and provides a robust, flexible waterproof seal. Avoid setting the transducer on bumpy surfaces that may leave an indentation in the urethane or damage the urethane face, anodized finish, or paint.



The Pathfinder housing contains Electrostatic Sensitive Devices. Take accepted ESD prevention measures **before** removing the housing.



The PWR/COMM cable connects the Pathfinder to the computer and external power supply. When the cable is not connected, use the connector protective cap to protect the connector.

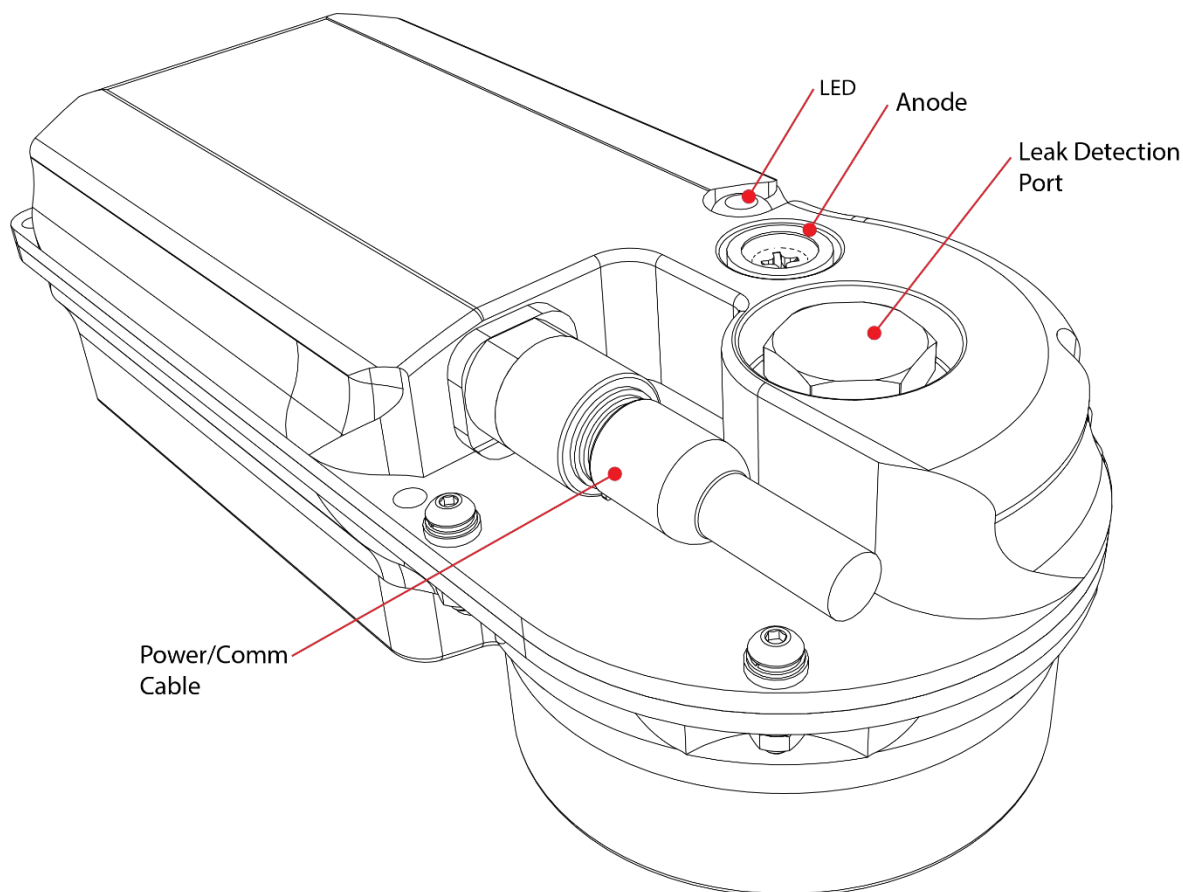


Figure 1. Pathfinder ROV Version

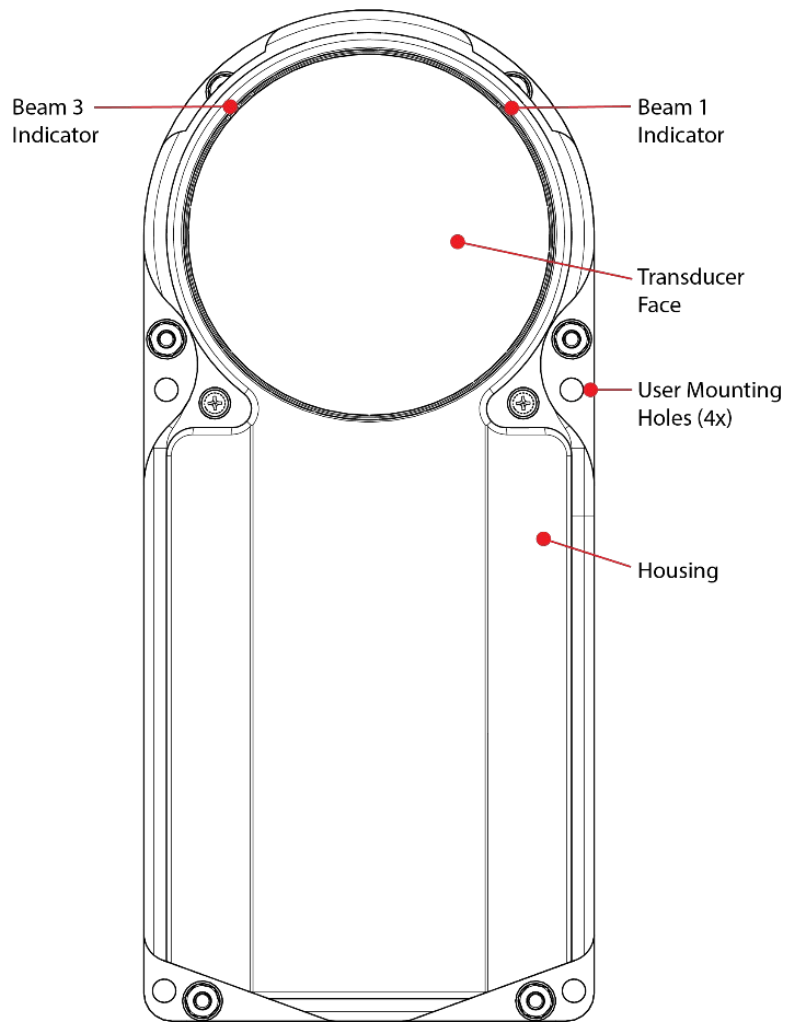


Figure 2. Pathfinder ROV Version Face View

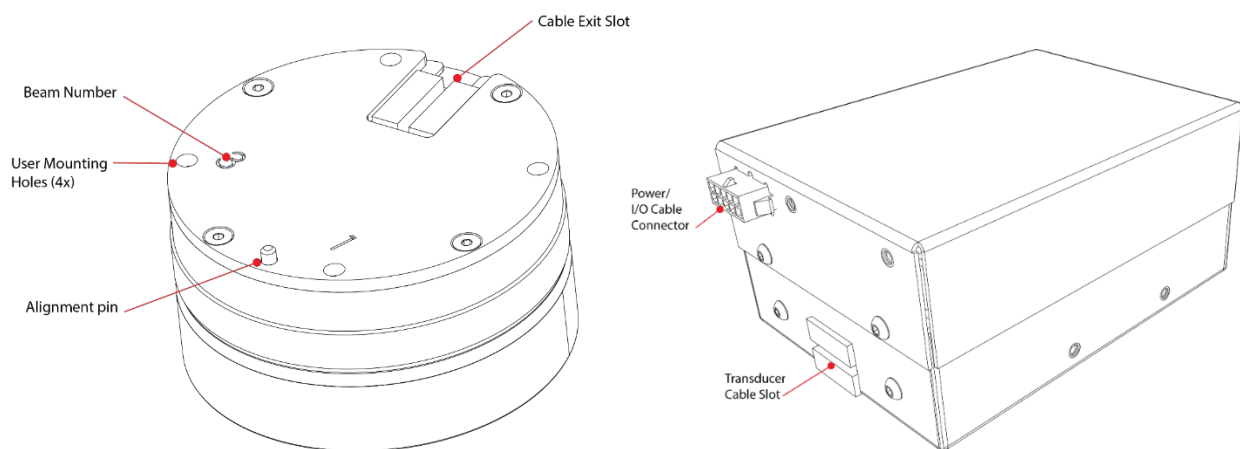


Figure 3. OEM Version Transducer and Electronics Chassis

Pathfinder Options

The following options are available:

- The 73B-6057-00 ROV test cable is used for testing the system prior to installing it on a ROV.
- The 73b-6059-00 OEM test cable is used for testing the system prior to installing it on a ROV.
- The Ethernet command and control port is included with all systems but can be removed upon request. This option must be selected when the system is ordered.
- Current Profiling Mode is a firmware upgrade.
- Low-altitude is a firmware upgrade.
- High accuracy Bottom Track is a firmware upgrade.
- XRT (Extended Range Tracking) firmware upgrade delivers 40% increase in bottom tracking range. This option requires FPGA version 1.00.012 installed (a factory upgrade). Systems shipped after October 2018 have this version installed. To verify if your system can be field upgraded, run the PSo command:

```
>ps0
Serial Number: 600006
Frequency: 614400 Hz
Configuration: DVL : 4-beam velocity.
Transducer Type: PHASEDARRAY
Beam Angle: 30 Degrees
Beam Pattern: CONVEX
Sensors: TEMP
CPU Firmware: 67.14
FPGA Version: 1.00.012 [0x100c]
```

```
Board Serial Number Data:
C5 00 00 08 A2 76 08 28 DS18B20 TMP SNS
2A 00 00 02 86 C7 02 23 XDR72B-1110-00C
05 00 00 02 6D 56 EA 23 ETH72B-2305-00B
4B 00 00 02 6E D2 61 23 DSP72B-2303-00A
62 00 00 02 6E D8 7B 23 PTX72B-2304-03A
74 00 00 02 62 26 7B 23 RCV72B-2302-03A
```

Supported Sensors

The following sensors are supported in the Pathfinder:

Sensor	Manufacturer	Model
Temperature	TRDI Internal in Transducer	Dallas 18B20 One Wire
Inclinometer	Analog Devices	TBD (Future Release)



For more information, see the [EZ Command](#).

Inventory

The following DVL Kits are available:

- **DVL Standalone:** This provides you an option to purchase the DVL with only the necessary parts to install it in your vehicle. This is especially adapted, once the first integration has been completed and therefore test cables and other accessories are no longer needed.
- **DVL Development Package:** The DVL Development Package is a complete package to integrate, evaluate and use your PathFinder DVL. The DVL Development Package was designed to help you start testing, configuring and integrating your new devices quickly.
- **DVL Integration Kit:** The DVL Integration Kit has been designed to save you both time and money by speeding up the evaluation and the integration of our products into your vehicle.
- **Field Service Kit:** The Field Service kit has been designed to allow you to service, repair, and test your DVL with the assumption that you do not have any kits already available.

Table 1. Pathfinder ROV System Inventory

Part Number	Name	Description
70B-9042-xx	Pathfinder ROV version	The Pathfinder ROV 600 kHz system includes the transducer and connector protective cap. When unpacking, use care to prevent physical damage to the transducer face and connectors. Use a soft pad to protect the transducer.
97B-7010-00	ROV hard Shipping Case	Shipping case with foam inserts.
73B-6058-00	ROV PWR/COMM Pigtail Cable	The DVL PWR/COMM pigtail cable allows you to build custom cable to connect the Pathfinder to your vehicle/platform. It provides all the leads for serial and Ethernet COM, Power and Trigger.
95B-6116-00 or 90Z-8002-00	Pathfinder DVL Software and Documentation CD	This CD has PDF versions of all of the Pathfinder DVL software and documentation including the Pathfinder DVL Guide. Please read the manual! The CD also includes the TRDI Toolz Software. TRDI Toolz is a utility and testing software package that can be used to test the DVL.
95B-6117-00	Pathfinder ROV Getting Started Guide	A printed quick start card showing test setup is included. A PDF version is included on the documentation CD.
95B-6119-00	Pathfinder ROV Integration Guide	A printed quick reference showing how to integrate the Pathfinder DVL onto a ROV. Refer to Chapter 2 of the Pathfinder DVL guide for detailed instructions.
ROV Spare Parts*	See table below for description	Anodes and closing hardware

Table 2. Pathfinder ROV Spare Parts*

Description	Part number	Where used
Anode, housing, top	81B-4146-00	Anodes for Housing Exterior
Anode, housing, bottom	810-4106-00	
Anode Screw	M5X0.8X10FH	
Anode Screw	M2.5X0.45X8FH	
M4 Washer	M4WASHMOD	Closing hardware for housing
M4 Split Washer	M4WASHSPL	
M4 Nylon Washer	M4WASHNYLON	
M4 Nut	M4X0.7NUT	
Isolator	91145A148	
M4 Bolt	M4X0.7X25SH	

Table 3. Pathfinder OEM Inventory

Part Number	Name	Description
70B-9043-xx	Pathfinder OEM version	The Pathfinder OEM 600 kHz system includes the transducer and electronics chassis. When unpacking, use care to prevent physical damage to the transducer face and connectors. Use a soft pad to protect the transducer.
97B-7011-00 97B-7012-00	OEM hard Shipping Case OEM cardboard	Shipping case with foam inserts.
73B-6060-00	OEM PWR/COMM Pigtail Cable	The DVL PWR/COMM pigtail cable allows you to build custom cable to connect the Pathfinder to your vehicle/platform. It provides all the leads for serial and Ethernet COM, Power and Trigger.
95B-6116-00 or 90Z-8002-00	Pathfinder DVL Software and Documentation CD	This CD has PDF versions of all of the Pathfinder DVL software and documentation including the Pathfinder DVL Guide. Please read the manual! The CD also includes the TRDI Toolz Software. TRDI Toolz is a utility and testing software package that can be used to test the DVL.
95B-6120-00	Pathfinder OEM Getting Started Guide	A printed quick start card showing test setup is included. A PDF version is included on the documentation CD.
95B-6121-00	Pathfinder OEM Integration Guide	A printed quick reference showing how to integrate the Pathfinder DVL onto a ROV. Refer to Chapter 2 of the Pathfinder DVL guide for detailed instructions.
OEM Spare Parts*	O-ring and Lubricant	Remote OEM Transducer head O-ring and lubricant

Table 4. Pathfinder OEM Spare Parts*

Description	Part number	Where used
O-RING, FACE SEAL, DURO 70	2-037	
CAP, PROTETIVE SHIPPING, EXP600 PA	4491K84	
SILICONE LUBRICANT, 4-PACK	5020	OEM Transducer
L-KEY, HEX, 2MM MCMaster-CARR	5503A37	
O-RING, -152, EPDM 70 DURO	2-152	

Optional Kits

Table 5. 75BK6086-00 – Kit, Integration, ROV Pathfinder

P/N	Description	QTY
73B-6057-00	Cable, Test, ROV, Pathfinder	1
73B-6046-00	Power cable with banana plugs	1

Table 6. 75BK6088-00 – Kit, Integration, OEM Pathfinder

P/N	Description	QTY
73B-6059-00	Cable, Test, OEM, Pathfinder	1

Table 7. 75BK6087-00 – Kit, Field Service, ROV Pathfinder

P/N	Description	QTY
M4WASHMOD	WASHER, SMALL OD, 8MM SST	14
M4WASHSPL	WASHER, SPLIT LOCK, SST	8
M4WASHNYLON	WASHER, FLAT, 9MM OD, NYLON	8
M4X0.7NUT	NUT, HEX, SST	8
91145A148	ISOLATOR, 1/4 LONG, SCREW #8, NYLON	8
M4X0.7X25SH	SCREW, BUTTON/SOCKET HEAD 316 SST	8
81B-4146-00	ANODE, PIONEER 300	2
810-4106-00	ANODE, SMALL OD	4
M5X0.8X10FH	SCREW, FLAT HEAD, SST	2
M2.5X0.45X8FH	SCREW, FLAT HD SKT HD, 316SST	4
2-152	O-RING, -152, EPDM 70 DURO	2
97Z-6084-01	O-RING, 3-094, .072DIAX.351 ID, EPDM, DURO90A, VENT PLUG	2
7295K1	TIE WRAP, FASTENER MOUNT, 4.5	2
97Z-6007-00	O-RING, 2-011, DURO 70, EPDM	4
97Z-6009-00	O-RING, 2-014 DURO 70, EPDM	2
97Z-6036-00	O-RING, 2-166, 70 DURO, EPDM	2
97Z-6084-00	O-RING, 2-015, 070DIAX.551 ID, EPDM, DURO 90A, VENT PLUG	2
DES6	DESICCANT, SEALED BAG, 1/6 UNI	1
5020	SILICONE LUBRICANT, 4-PACK	2
425	THREADLOCKER, PLAS SCREW	1
81B-6042-00	O-RING TOOL, TELEDYNE	1
M7COMBINATION	WRENCH, #7MM COMBINATION	1
7289A13	KEY, HEX, 2.5MM	1
84Z-6000-00	TOOL BAG, CANVA	1
95B-6116-00	Pathfinder DVL Documentation CD	1
95B-6117-00	Pathfinder DVL Quick Start Card	1

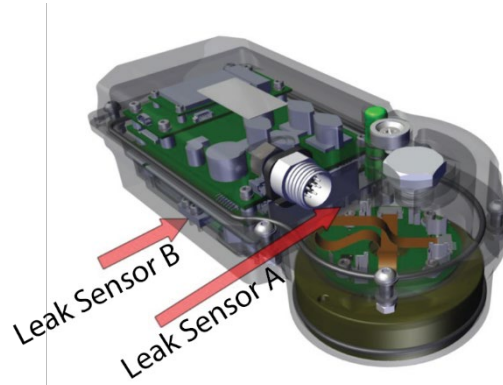
Table 8. 75BK6089-00 – Kit, Field Service, OEM Pathfinder

P/N	Description	QTY
5020	SILICONE LUBRICANT, 4-PACK	2
2-037	O-RING, FACE SEAL, DURO 70	2
84Z-6000-00	TOOL BAG, CANVAS	1
7289A13	KEY, HEX, 2.5MM	1
5503A37	L-KEY, HEX, 2MM	1
81B-6042-00	O-RING TOOL, TELEDYNE	1
95B-6116-00	Pathfinder DVL Documentation CD	1
95B-6117-00	Pathfinder DVL Quick Start Card	1

Health & Environment Monitoring Sensors

Health and Environment Monitoring (HEM) Sensors monitor the health of the Pathfinder system.

- **Leak Detection** – Water leaking into a Pathfinder DVL can not only potentially destroy the DVL, but also cause severe issues for the host vehicle that is carrying the DVL, such as loss of navigation ability. The Pathfinder detects water leaking into the system and reports it in the PD0, PD4, PD5, and PD6 messages. The Pathfinder also supports the [PC4](#) and [PC5 user interactive test](#) for reporting the status of the leak sensors. There are two leak sensors; One is mounted at the back of the transducer head and the other at the bottom of the electronic section (Leak Sensor B is only available on the ROV Self-Contained version).



- **Transducer Monitor** – The Pathfinder monitors the transmit voltage and current of the transducer and reports Transducer Impedance as a result. This information provides insight, in near real-time, to the status of the transducer and alerts the user should problems arise. This data is relayed back to the user in the [PD0 Bytes 76 and 77](#) and [PD6 output data structure](#).
- **Operating Time** – The Pathfinder system records the total time of operation in minutes where “operation” is defined as the time that the system ping loop is active (CS command has been sent). The record of the total awake time has a maximum value of 33,554,432 minutes, which corresponds to over 500,000 hours of operation. The value of the counter can be read as part of the [PS5 command](#). Although the time is stored in minutes, the operating time is reported in hours with one decimal place.

Example PS5 output:

```
PS5
Operating time: 4327.5 hours
```

Setting up the Pathfinder System

Use this section to connect the Pathfinder to a computer and establish communications. Install the *TRDI Toolz* software in order to communicate with the Pathfinder.

Computer and Software Considerations

The Pathfinder system includes the utility program *TRDI Toolz* to help set up, use, test, and troubleshoot the Pathfinder. Use this program to “talk” to the Pathfinder and to run script files (see [Creating or Modifying Command Files](#) and [send the Commands to the Pathfinder](#)). For detailed information on how to use *TRDI Toolz*, see the *TRDI Toolz* Help file.

NavUI can be used directly via Ethernet with a PathFinder DVL. *NavUI* can also be used ‘behind’ a TSS TOGSNAV or TOGSINS and the DVL data is ‘relayed’ (by the TOGS) to *NavUI* using UDP. *NavUI* can decode any DVL PDO data received from ‘the INS’ connection.



For information on *NavUI*, see the *NavUI* documentation.

TRDI designed the Pathfinder to use a Windows® compatible computer. Table 8 lists the minimum computer requirements.



TRDI highly recommends downloading and installing all the critical updates, recommended updates, and the service releases for the version of Windows® being used prior to installing any TRDI software.

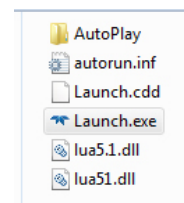
Table 9: Minimum Computer Hardware Requirements

Windows® 7, 8.1, or 10
1GHz class PC 32-bit (64-bit recommended)
2GB of RAM (4GB or more RAM recommended)
50 MB Free Disk Space plus space for data files (A large, fast hard drive is recommended)
Minimum display resolution of 1024 x 768, 256 color (higher recommended)
CD-ROM Drive (if software is installed from CD)
Mouse or other pointing device

Software Installation

To install the Pathfinder Software and Documentation CD:

1. Insert the CD into the drive.
2. Use Windows Explorer® to open the CD drive folder.
3. Double-click on the *launch.exe* file. When the browser starts:
 - To install TRDI Toolz, click the **View Manuals** button and then click the **Install TRDI Toolz** button.
 - To view the Pathfinder documentation, click the **View Manuals** button.



Many companies require that Autorun be disabled. Double-click on *Launch.exe* to start the browser on all TRDI software and documentation CDs.

Power Overview

The Pathfinder requires a DC supply between 10.7 to 36 VDC. Either an external DC power supply or battery can provide this power. The power supply should be able to source at least two Amps for a bench test setup (no pinging).

Power on Cycle

The power supply must be able to handle the inrush current as well. Inrush current is the current required to fully charge up the capacitors when power is applied to the Pathfinder. The capacitors provide a store of energy for use during transmit. The inrush current is as much as four amps if plugged in after the DVL Transmit Cap is fully discharged. The Pathfinder will draw this amperage until its capacitors are fully charged (less than 200ms).



If the power supply limits the current or the power drop on the cable is significant, then the power on cycle will fail or the system will reset during pinging. Therefore, TRDI recommends a 1.5 to 2 Amp power supply to cover all performance cases. For more information, see [Electrical Specifications](#).



If the Power is put in then removed within a very short time (few secs) and then applied again, then the Inrush limiter will not be able to limit the current pulled from the DVL which would result in a higher than 4Amps Inrush current spike.

Cables and Connector Protective Cap

The underwater cables connector protective cap is a molded wet-mate-able connector. The end-cap connectors are a factory-installed item. TRDI does not recommend removing it for any routine maintenance.



The connector protective cap should be installed any time the cable is removed. Use the protective connector cap when the DVL is in storage or is being handled.

Prior to each connection:

1. Lubricate the connector by placing a light amount of silicone lubricant on the female cable connector mating surfaces (rubber portion only). Silicone lubricant is included in the Spare Parts kit.



Use **ONLY** silicone-based lubricants. **DO NOT** use petroleum-based lubricants.



Apply lubricant prior to each connection. Lubricant aids seating the connector and helps form a watertight seal as the locking sleeve is tightened.

To connect the cable:

1. Check all pins for signs of damage (broken or bent pins or corrosion).
2. Push the cable straight onto the connector ensuring the pins are properly aligned. While keeping a slight inward pressure on the cable connector and ensuring that the connector is straight, thread the locking sleeve onto the receptacle to complete the connection.



Do NOT use any tools to tighten the locking sleeve. It should only be “finger tight”.

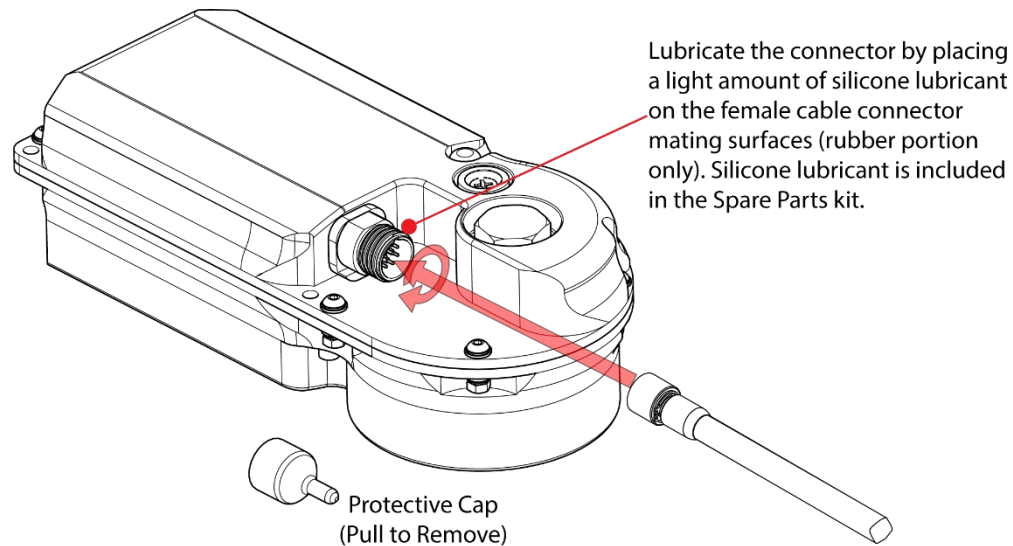


Figure 4. Connecting the Cable



Lubricate the connector by placing a light amount of silicone lubricant on the female cable connector mating surfaces (rubber portion only). Silicone lubricant is included in the Spare Parts kit.

To disconnect the cable:

1. Place the Pathfinder on a soft pad to protect the transducer face.
2. Release the cable by turning the locking sleeve counter-clockwise until it can be moved away from the connector.
3. Pull the cable straight out away from the housing.
4. Install the connector protective cap to protect the connector pins.

Setting Up the Pathfinder ROV System

To set up the Pathfinder:

1. The Pathfinder cable connector must be lubricated **before each connection**. Lubricate the connector by placing a light amount of silicone lubricant on the female cable connector mating surfaces (rubber portion only). Silicone lubricant is included in the Spare Parts kit.
2. Place the Pathfinder on its transducer face on a soft pad. Remove the Power/Comm connector protective cap and push the cable straight onto the Power/COMM connector ensuring the key and pins are properly aligned. While keeping a slight inward pressure on the cable connector and ensuring that the connector is straight, thread the locking sleeve onto the receptacle to complete the connection.



Do NOT use any tools to tighten the locking sleeve. It should only be “finger tight”.

3. Attach the Power/Comm cable to the computer's serial communication port or Ethernet port.
4. Place the Pathfinder system in water (at least a few inches to cover the transducer face).
5. Connect the power adapter cable to the Power/Comm cable power connector by pushing it all the way in until it “clicks” and then turn the locking sleeve to secure the connection. Connect +10.7 to 36 VDC power using the banana plugs. The power supply should be able to source at least two Amps for a bench test setup (no pinging).

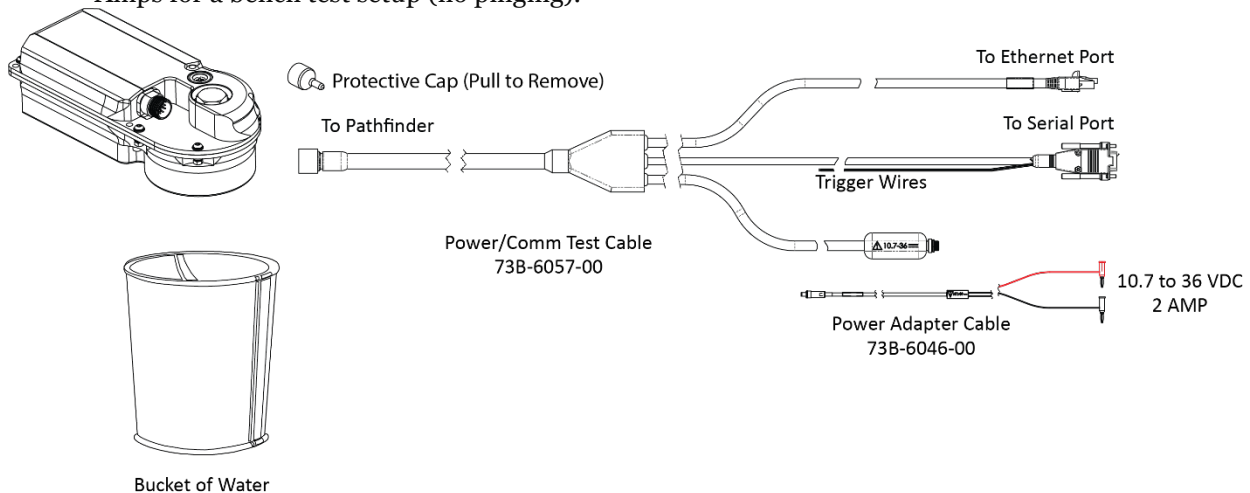


Figure 5. ROV Pathfinder Connections for Bench Test [73B-6057-00 & 73B-6046-00 Cables]

Setting Up the Pathfinder OEM System

To set up the OEM Pathfinder:

1. Place the Pathfinder transducer face down on a soft surface.
2. With an ESD wrist strap on, remove the top cover on the transducer. Loosen, but do not remove the two screws next to the cable exit slot.
3. Connect the five cables and ground wire. The 3-pin beam cables have the beam number on the connector and are color-coded: Beam 1 = black, Beam 2 = red, Beam 3 = yellow, Beam 4 = blue. Attach the only 4-pin connector to the board.
4. Remove the screw and attach the ground wire lug. Tighten the ground screw to 4 IN-LB.
5. Thread the cables through the slot and attach the cover. Tighten the four M3 screws on the cover to 4 IN-LB. Tighten the two screws next to the cable exit slot to hold the cables in place.
6. Connect P1 to the Electronics Chassis.
7. Attach the Power/Comm cable to the computer's serial or Ethernet communication port.
8. Connect +10.7 to 36 VDC power. The power supply should be able to source at least 1.5 to 2 Amps.

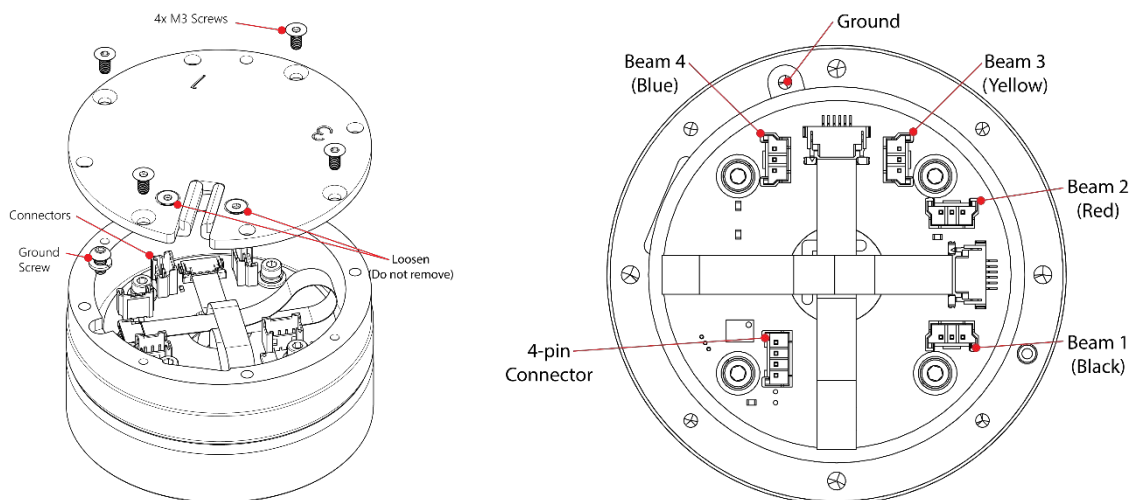
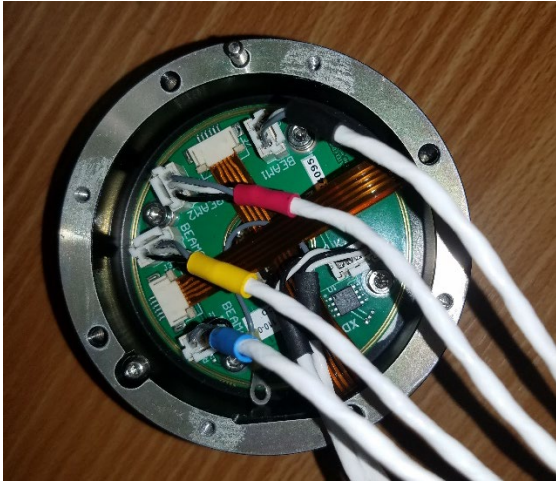


Figure 6. OEM Pathfinder Transducer Connections



The standard length of the cable between the transducer and chassis is 12”.



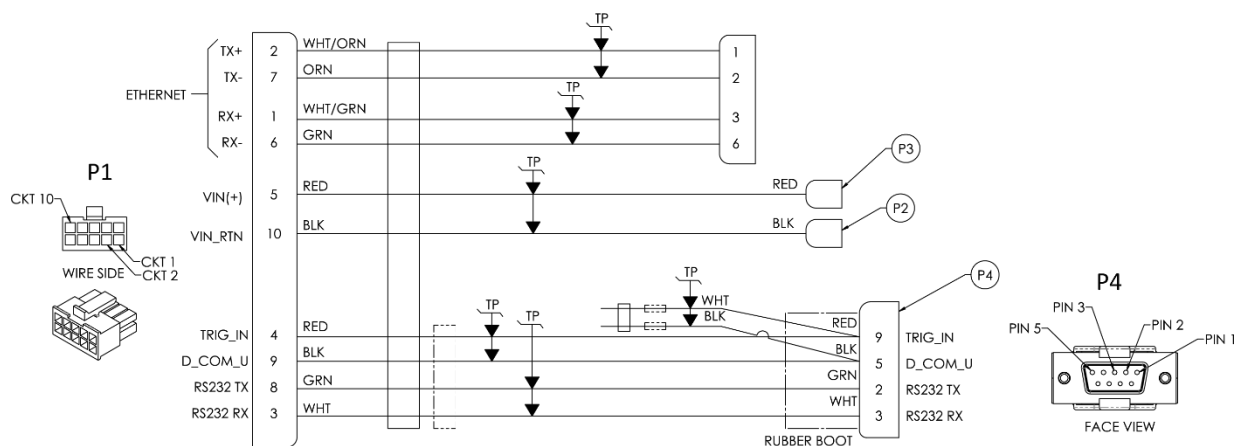


Figure 7. OEM Pathfinder Connections for Bench Test [73B-6059-00 Cable]

Cable Wiring Diagrams

This section has information on Pathfinder cabling. Special user-requests may cause changes to the basic wiring system and may not be shown here. If there is a conflict, contact TRDI for specific information about the system. The following figures show various Pathfinder cable locations, connectors, and pin-outs.

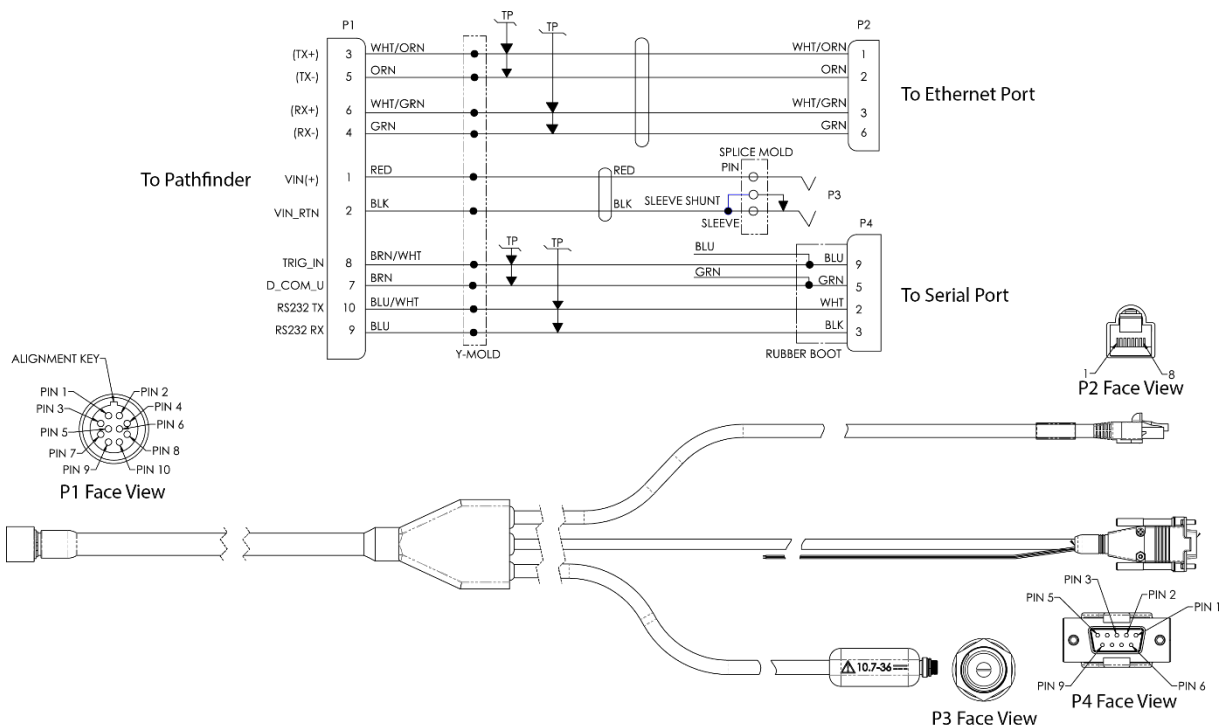


Figure 8. Pathfinder Power/Comm Cable 73B-6057-005 Optional Test Cable



The connector protective cap should be installed any time the cable is removed. Use the connector protective cap when the Pathfinder is in storage or is being handled.

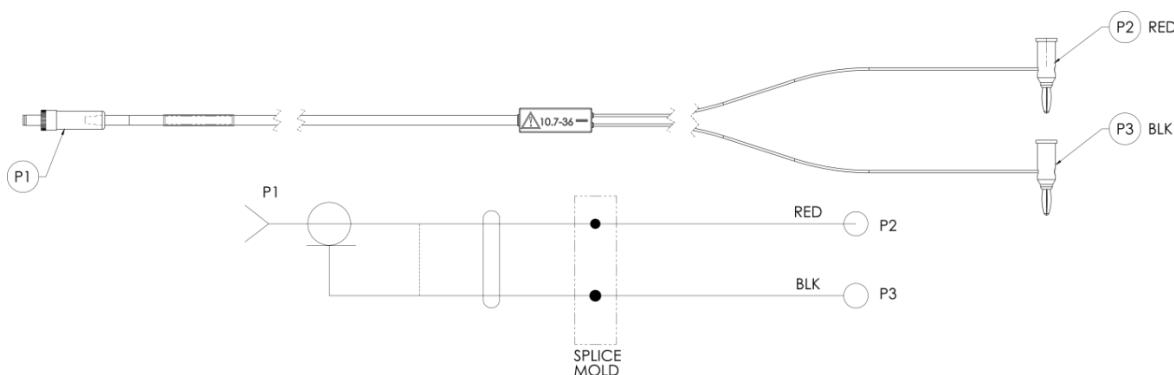


Figure 9. Power Adapter Cable 73B-6046-00

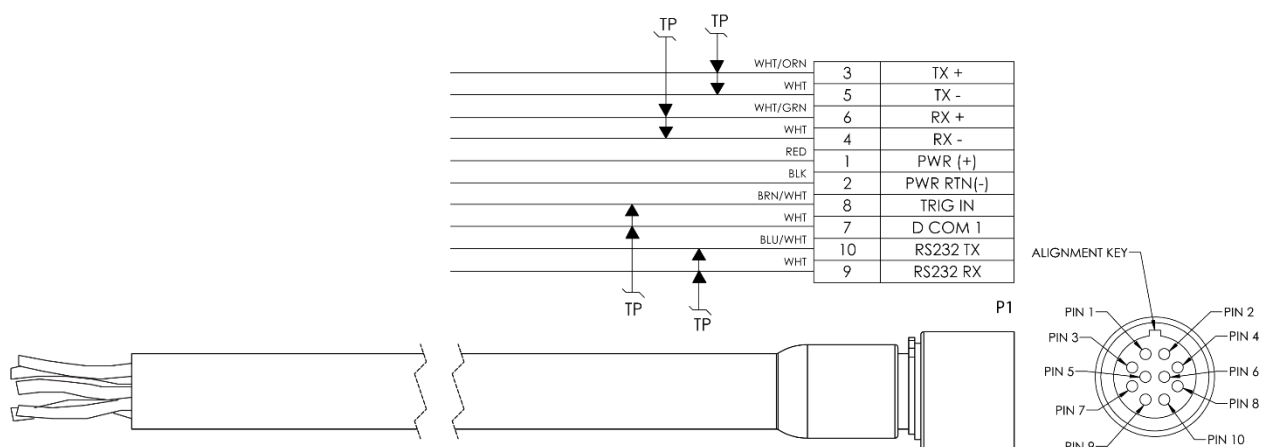


Figure 10. Pathfinder ROV Power/Comm Cable 73B-6058 Pigtail Cable



Where shown, RX is the incoming signal; TX is the outgoing signal.

Cable bend radius is 4.5 inches. The connector part number is MKS(W)-3L10-CCP-SB from Teledyne Impulse.

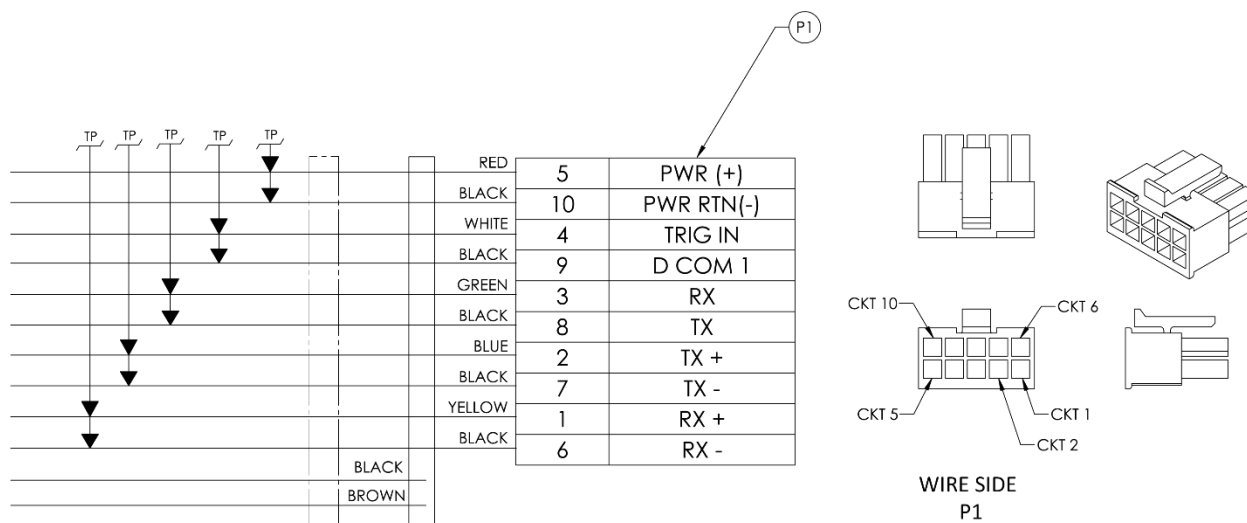


Figure 11. Pathfinder OEM Power/Comm Cable 73B-6060 Pigtail Cable

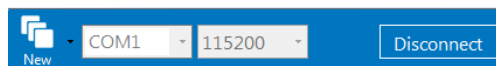
Connecting to the Pathfinder

To establish communications with the Pathfinder:

1. Connect the system and apply power.
2. Start the *TRDI Toolz* software.
3. Select **New Serial Connection** or **New Ethernet Connection**.
4. Enter the Pathfinder's communication settings.

Serial Communications:

Select the **COM Port** the serial cable is connected to and set the **Baud Rate** from the drop-down list to 115200



Ethernet Communications:

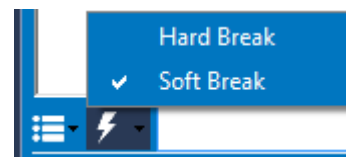
Enter the Static DHCP server **IP or host name** 192.168.1.100

Enter the **Port Number** 1033

Select **TCP**



5. Click the **Connect** button. Once connected, the button will change to **Disconnect**.
6. Click the **Break** (⚡) button. From the **Break** button drop down menu, select **Soft Break** (= = =). The wakeup banner will display in the terminal window.



```
Pathfinder
Teledyne RD Instruments (c) 2017
All rights reserved.
Firmware Version: 67.xx
```

>



It may be necessary to click inside the terminal window and then click the **Break** button to wake up the system.



If the network assigns a Dynamic IP address, the Static IP address **192.168.1.100** will not work; Connect using the serial port and use the [CE command](#) to verify the IP address.



You must have the RJ45 connector plugged into the network switch for the CE command to return the Ethernet setting info.



The command and control port can be Serial or Ethernet, but NOT both. The last port used to send a break is the command and control port.

7. The LED should be solid on if no data is moving over the serial port and there is no active TCP/IP connection on the Ethernet interface.
 - The LED will blink 250ms/500ms when there is data on the serial port.
 - The LED will blink 250ms/1000ms when there is traffic on the Ethernet port.

Using the Network Configuration Page



The system must be connected to the Ethernet port to use the Network Configuration page.

To establish communications with the Network Configuration page:

1. Connect the system and apply power.
2. Open a browser on the laptop (*Internet Explorer®*, *FireFox®*, *Google Chrome®*, or other browser).
3. Enter the Pathfinder's DHCP server IP address **192.168.1.100** into the address bar.
4. On **Network Configuration**, choose **STATIC** or **DHCP**. Use Dynamic Host Configuration Protocol (DHCP) server protocol when the network automatically provides an Internet Protocol (IP) host with its IP address and other related configuration information such as the subnet mask and default gateway.

If you are using a STATIC network, then configure the **Base IP Address**, **Network Mask**, **Gateway Address**, **Name Server Address**, and **Command/Control Port** as needed. The default configuration is shown in Figure 12.

5. On the Output Formats section, enable or disable the output data formats (PD0, PD4, PD5, PD6, PD11, PD13 and PS26), **Protocol (TCP or UDP)**, **Address**, and **Ports**. Once done, click **Submit**.



If all outputs are enabled, it can affect the ping rate.

Pathfinder 600 Network Configuration Update
Software Version v1.03

Network Settings

Network Configuration: STATIC Link Status: Not Active

Base IP Address: 192.168.1.100

Network Mask: 255.255.255.0

Gateway Address: 192.168.1.1

Name Server Address: 192.168.1.1

Command/Control Port: 1033

Output Formats

FORMAT	ENABLE	PROTOCOL	ADDRESS	PORT
PD0	ON	UDP	192.168.1.2	1034
PD4	OFF	TCP	192.168.1.1	1035
PD5	OFF	TCP	192.168.1.1	1036
PD6	OFF	TCP	192.168.1.2	1037
PD11	OFF	TCP	192.168.1.1	1038
PD13	OFF	TCP	192.168.1.1	1039
PD26	OFF	TCP	192.168.1.1	1040

Submit Reset

TELEDYNE
RD INSTRUMENTS
Everywhere you look

Figure 12. Pathfinder Network Configuration Page

Using the Ethernet Communications

Pathfinder systems supports an optional Ethernet output. These systems must be factory configured. Ethernet can be used for following scenarios:

- Send commands to the ADCP and receive responses on the CMD channel. The CMD channel is used to connect to a Pathfinder system and control it using a two-letter command system and must use port 1033. Use *TRDI Toolz* software to connect to this port using TCP protocols to control the Pathfinder system.
- Send data from the Pathfinder to user equipment such as a PC or a data logging device. The data channel is established over a UDP socket.

It is possible to output ensemble data in two ways:

1. Send ensemble data to a specific destination IP and port number using TCP protocol.
2. Send ensemble data to a network directed broadcast IP and port number using UDP protocol.

Using TCP Protocol

In the example below a TCP PDO stream was created on port 1034:

Network Settings

Network Configuration		STATIC ▼	Serial Link Status	
Base IP Address	192.168.1.100		Active	
Network Mask	255.255.255.0			
Gateway Address	192.168.1.1			
Name Server Address	192.168.1.1			
Command/Control Port	1033			

Output Formats

FORMAT	ENABLE	PROTOCOL	ADDRESS	PORT
PDO	ON ▼	TCP ▼	192.168.1.2	1034
PD4	OFF ▼	TCP ▼	192.168.1.1	1035

To be able to listen to this stream, you will need to create a TCP connection to the PathFinder DVL IP address, here 192.168.1.100 through port 1034. This can be done in *TRDI Toolz* for verification.

Using UDP Protocol

In this example below, a PD0 stream was created over UDP on port 1034:

The image shows two side-by-side screenshots. The left screenshot is the 'Pathfinder 600 Network Configuration' window. It has a 'Network Settings' section with fields for Base IP Address (192.168.1.100), Network Mask (255.255.255.0), Gateway Address (192.168.1.1), Name Server Address (192.168.1.1), and Command/Control Port (1033). There is a 'Link Status' button showing 'Not Active'. Below this is an 'Output Formats' table.

FORMAT	ENABLE	PROTOCOL	ADDRESS	PORT
PD0	ON	UDP	192.168.1.2	1034
PD4	OFF	TCP	192.168.1.1	1035
PD5	OFF	TCP	192.168.1.1	1036
PD6	OFF	TCP	192.168.1.2	1037
PD11	OFF	TCP	192.168.1.1	1038
PD13	OFF	TCP	192.168.1.1	1039
PD26	OFF	TCP	192.168.1.1	1040

At the bottom of the configuration window are 'Submit' and 'Reset' buttons. The right screenshot is the 'TRDI Tools 1.01.00.07' window. It shows a 'New' connection setup for IP or host name '1034' using the 'UDP' protocol. The 'Disconnect' button is visible. Below the connection bar, there is a list of active connections with columns for IP or host name and port. The first connection is highlighted: IP or host name: 1034, port: 1034.

To be able to listen to that UDP stream, you will need to make sure the UDP IP address matches the computer's IP address. The computer's IP address can be found using ipconfig in a command prompt window.

The computer's IP address can also be found by using Control Panel. Navigate to **Network and Internet\Network and Sharing Center**. Click on **Local area Connection x** under View Active networks. Click on **Properties** and then click on **Internet protocol Version 4 (TCP/IPv4)**. Click on the **Properties** button, and then verify the computer's IP address.

In this next example, the computer's IP address is 192.168.1.2. Therefore, set the UDP IP address on the web portal to be the same. You can now simply open a UDP stream to listen to that PD0 feed simply by using the port number, here in our example 1034.

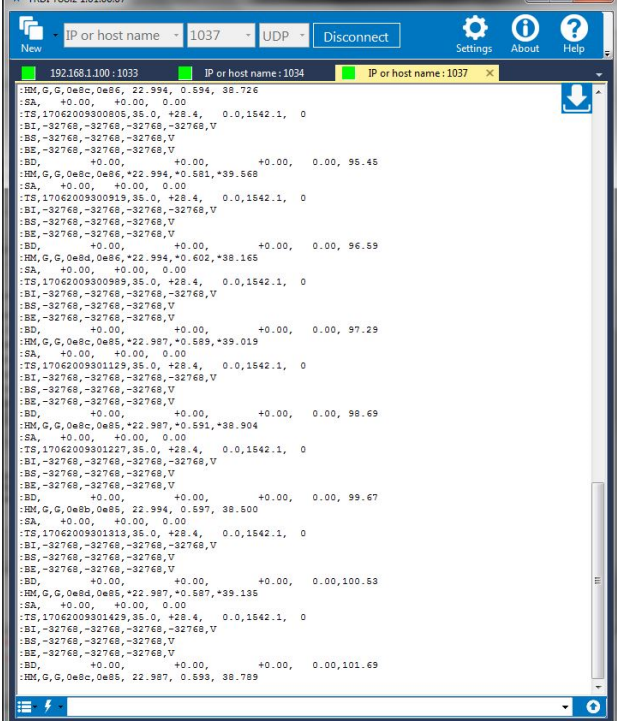
This example also includes a PD6 stream over UDP on port 1037 that points to the computer's IP address 192.168.1.2 – here is the snapshot from listening to this stream using *TRDI Toolz*:

Network Settings

Network Configuration		STATIC
Base IP Address	192.168.1.100	
Network Mask	255.255.255.0	
Gateway Address	192.168.1.1	
Name Server Address	192.168.1.1	
Command/Control Port	1033	

Link Status

Not Active



Output Formats

FORMAT	ENABLE	PROTOCOL	ADDRESS	PORT
PD0	ON	UDP	192.168.1.2	1034
PD4	OFF	TCP	192.168.1.1	1035
PD5	OFF	TCP	192.168.1.1	1036
PD6	ON	UDP	192.168.1.2	1037
PD11	OFF	TCP	192.168.1.1	1038
PD13	OFF	TCP	192.168.1.1	1039
PD26	OFF	TCP	192.168.1.1	1040

Submit

Reset



UDP is a connection-less protocol. Therefore, UDP packets can be lost in an unreliable or highly congested network.

The Ethernet portion of the DVL acts as a server on (potentially) several fronts:

1. Command/Control of the DVL happens via the TCP port on the command interface (default port 1033). The DVL acts as a server and will accept a connection from any IP on the subnet.
2. Configuration of the PDx outputs and general IP config happens via the webpage (default IP 192.168.1.100, port 80) (acts as HTTP server).
3. PDx output happens on one of several ports:
 - a. Each PDx (PD0, PD4, PD5, PD6, PD11, PD13 and PD26) can be configured to be output on a separate port.
 - b. Each can be configured to output via TCP or UDP.
 - c. TCP connections can be made from any address – you will connect to the same IP address as the webpage, and on the specified port. For example, by default only PD0 is enabled. One would connect a TCP client to 192.168.1.100 at port 1034. The DVL acts as a server and will accept a connection from any IP.
 - d. UDP connections will be broadcast by the Ethernet module to the specified Address and port. By default, these broadcast to 192.168.1.1 on ports 1034 through 1038. For example, one could configure PD4 to output on UDP, to IP 192.168.1.1 on port 1035, then one would need a UDP client on a machine at address 192.168.1.1 listening to port 1035. One can

also configure the UDP to use the “broadcast” address such as 192.168.1.255, which would send traffic to the whole 192.168.1.xxx subnet. The DVL acts as a server and outputs this data whether a UDP client is connected or not (given the connectionless nature of UDP.)

4. The Ethernet module will NOT act as a DHCP server (can be configured to be a DHCP client, or to use static addressing). HOWEVER, when configured as a DHCP client, the unit will “failover” to using the specified “static” IP address (192.168.1.100, by default) if it times out when looking for a DHCP server. This prevents the unit from being “unreachable” if placed on a network without a server.



A reminder than in all cases, there **MUST** be a TCP client connected to the command/control Address/Port for any of the other PDx traffic to be output. The nominal case would be to install *TDRI Toolz*. Select **Ethernet Connection**, set **IP or host name** to 192.168.1.100, port 1033 and TCP. This presumes the PC in use is on the same 192.168.1.xxx subnet (since this is a non-routable IP.)

Ethernet Module Firmware Update



Firmware version 67.20 and above adds support for firmware updates over Ethernet. This requires Ethernet Module Firmware version 1.04 or higher. See [Installing Firmware and Feature Upgrades](#).

To install an Ethernet module firmware update:

1. Use our online customer portal at <http://www.teledynemarine.com/rdi> and click on the **Support** link to download the firmware update. Log into your account and then click the **Software/Firmware** link. Save the file to the computer and unzip the file. The file will be *PF_xx.xx.xx.xx.bin* format where xxxx = firmware version.
2. Connect to the Pathfinder Network Configuration Page.
3. On the upper right corner, select **Update**.



Pathfinder uDVL Network Configuration

Firmware Upload

Current Firmware	v0.03
Select New Firmware File	Choose File No file chosen
Update	

Note: This operation may take up to 60 seconds

4. Click the **Choose file** button and locate the firmware file *PF_xx.xx.xx.xx.bin* file downloaded in step 1. Select the file and click **Update**.
5. The firmware will install.
6. Once the firmware update is complete, the Pathfinder will reboot. Close the browser and reconnect to the Pathfinder Network Configuration Page.
7. If the new firmware does not install, contact Customer Service.

Testing the Pathfinder System

To test the Pathfinder:

1. Interconnect the system as described in Setting Up the Pathfinder System.
2. Place the Pathfinder transducer in water (at least a few inches to cover the transducer face).
3. Apply power to the system.
4. Start the *TRDI Toolz* program (for help on using *TRDI Toolz*, see the TRDI Toolz Help file).
5. Click the **Break** button. The wakeup banner appears on the log file window.

```
Pathfinder
Teledyne RD Instruments (c) 2015
All rights reserved.
Firmware Version: 67.xx
>
```

6. At the ">" prompt in the communication window, enter the command **CR1** then press the **Enter** key. This will set the Pathfinder to the factory default settings.
7. At the ">" prompt in the communication window, enter the command **CK** then press the **Enter** key. This will save the factory default setting.
8. At the ">" prompt in the communication window, enter the command **PS0** then press the **Enter** key. This will display the Pathfinder system configuration data.

```
>ps0
Serial Number: 0
Frequency: 614400 Hz
Configuration: DVL : 4-beam velocity.
Transducer Type: PHASEDARRAY
Beam Angle: 30 Degrees
Beam Pattern: CONVEX
Sensors: TEMP
CPU Firmware: 67.00c MH0
FPGA Version: 1.00.003 [0x1003]
```

```
Board Serial Number Data:
FF 00 00 08 0A 1A E1 28 DS18B20 TMP SNS
52 00 00 02 7B 85 3C 23 ETH72B-2305-00A
5F 00 00 02 61 E5 71 23 DSP72B-2303-00A
B5 00 00 02 1A 90 C3 23 PTX72B-2304-00A
C3 00 00 02 63 57 0B 23 RCV72B-2302-03A
C6 00 00 02 7B 8C F7 23 XDC72B-1110-00B
```

9. At the ">" prompt in the communication window, enter the command **PA** then press the **Enter** key. This will run the Pathfinder Pre-Deployment test.



Submerge the transducer face in a few inches of water. **The PA test may fail in air.** Only a failure with the transducer in water is a relevant test.



This test may fail if the Pathfinder is exposed to electrical interference such as that from other acoustic devices or SONARs or other electronic devices (i.e. cellphones, radios, computers, TV's, etc.). The test may also fail if the Pathfinder or its cable is exposed or installed near potential sources of EMI's such as high voltage lines like main engine cables, galley equipment, winches, engine room equipment, cranes, high voltage lighting circuit, etc. Interference from the mentioned sources may contaminate the Pathfinder's data as well. Oftentimes, a noisy (i.e. non-UPS) power supply may cause failures in this test as well.

```
>PA
ROM Test...PASS [ 3aad ]
RAM test...PASS
FRAM test...PASS
Receive Buffer Test...PASSED
XMIT RAM Test...PASSED
Receive Path Test (Hard Limited)...PASSED
Transmit/Receive Continuity Check...PASSED
```

```
Composite Result:
GO for Deployment
```

10. If the wakeup displays, PSo displays, and PA message displays with a result of “GO for Deployment”, the Pathfinder is functioning normally.
11. If the result shows “NO-GO for deployment” then run a PT200 test to obtain a more detailed log of the failure. See [Troubleshooting EMI](#) for more information.

Caring for the Pathfinder System

This section contains a list of items to be aware of every time handling, using, or deploying the Pathfinder. *Please refer to this list often.*

General Handling Guidelines

- Never set the Pathfinder transducer on a hard or rough surface. **This may leave an indentation in the urethane or damage the urethane face, anodized finish, or paint.**
- Do not expose the transducer face to prolonged sunlight (24 hours or more). **The urethane face may develop cracks.** Cover the transducer face on the Pathfinder if it will be exposed to sunlight.
- Do not store the Pathfinder in temperatures over 60 degrees C or under -25 degrees C. **The internal components and/or urethane face may be damaged.**
- Do not scratch or damage the O-ring surface or grooves on the transducer. **If scratches or damage exists, they may provide a leakage path and cause the Pathfinder to flood.** Do not risk a deployment with damaged O-ring surface.
- Do not lift or support a Pathfinder by the external cables. **The connector or cable will break.**
- Apply lubricant prior to each cable connection. **Regular lubrication is required: Apply silicone lubricant prior to each connection.**
- Do not connect or disconnect the cables with power applied. When the cable is connected with power applied, it may cause a small spark. **The connector pins may become pitted and worn.**
- The cables may be connected while slightly wet; do not connect under water.

Installation Guidelines

- Loose, missing, stripped hardware or damaged O-rings can **lead to water ingress and damage the Pathfinder.**
- **Do not connect other metal to the Pathfinder.** Other metals may cause corrosion damage. Isolating bushings must be used when mounting the Pathfinder to a metal structure if the transducer is bolted to the vehicle.

Chapter 2

SYSTEM INTEGRATION



In this chapter, you will learn:

- DVL Theory
- Mechanical Integration Considerations
- Electrical Integration Considerations
- Acoustic Integration Considerations
- Reference, Data & Timing Considerations
- PathFinder DVL Sensor Integration
- Operational and Setup Considerations

System Integration Introduction

This chapter is intended to provide both the basic operating theory and the necessary and often critical implementation and integration considerations for the use of DVL systems on various platform types. In addition, the procedures described provide a step-by-step guide that will enable the client to configure the Pathfinder DVL sonar for optimum utilization.

DVL Theory

BroadBand Doppler

Doppler sonars by definition, measure the Doppler shift, i.e. the frequency shift due to the relative motion of the DVL to either the seabed or suspended scatter particles in the water column. TRDI uses a more precise method of measurement that is a refinement to standard Doppler phase shift measurements called BroadBand. The methodology uses time dilation, by measuring the change in arrival times from successive acoustic pulses. TRDI uses phase to measure time dilation instead of measuring frequency changes because the phase measurement gives a more precise Doppler shift measurement.

TRDI also incorporates a technique called autocorrelation for error checking and thus a further refinement of velocity measurements. Autocorrelation works by transmitting a series of coded pulses, all in sequence and inside a single long pulse. The resulting received signal is composed of many echoes from many scatterers, all combined into a single echo. The propagation delay is extracted by computing the autocorrelation at the time lag separating the coded pulses. The success of this computation requires that the different echoes from the coded pulses (all buried inside the same echo) be correlated with one another.

Bottom Tracking

Bottom tracking is implemented using separate pings from water profiling. The transmit pulse is a longer duration, and the received acoustic signal incorporates a different processing scheme.

While water-profiling uses short transmit pulses to obtain vertical resolution, Bottom Tracking requires long duration pulses. Long pulses are utilized because this provides ensonification over a larger bottom area for each individual pulse (Figure 13).

If the pulse is too short or long, the echo returns first from the leading edge of the beam, followed later by the trailing edge. Because the beam has a finite beam width, the angle of the beam relative to the horizontal is different on these two edges, thus resulting in a Doppler shift that is different from one side of the beam to the other. By illuminating the bottom across the beam all at once, a long pulse produces an accurate and stable estimate of velocity, more accurate than is typically obtained from water profiles.

The disadvantage of long transmit pulses is that a considerable part of the echo can come from water-mass echoes. Where water-mass echoes are weak relative to the bottom echo, there is no adverse impact. For environments with high concentrations of suspended sediment (i.e. in some rivers) the water-mass echoes can introduce significant water bias. The added water bias causes an undesirable shift of the bottom-track velocity toward the ambient water velocity.

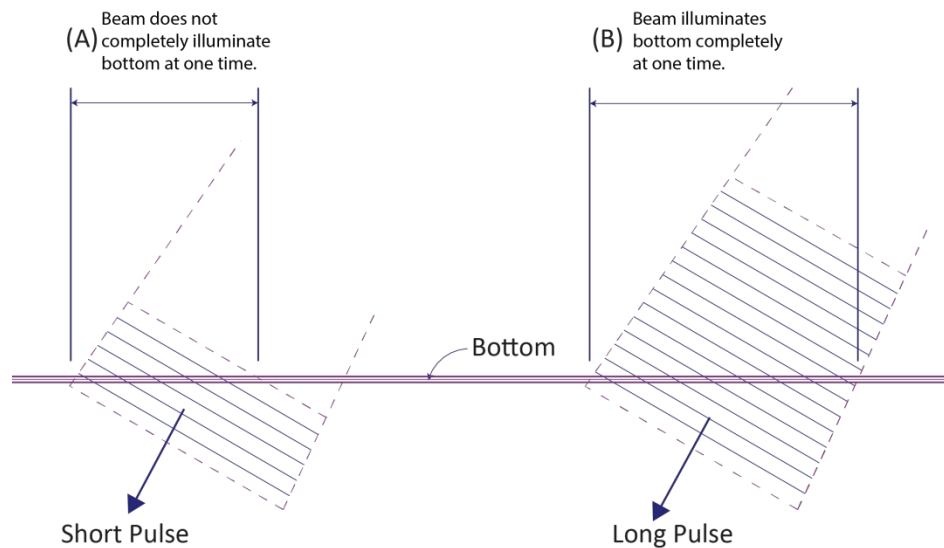


Figure 13. Short Pulse versus Long Pulse

A long Pulse is needed for the beams to ensonify (illuminate) the entire bottom all at once.

Water Tracking

Water tracking is used when the bottom is out of range or a reference velocity is desired. All TRDI DVLs are configured to provide Water Tracking data. Water tracking is desirable in situations where the bottom is not always within range of the DVL because of suspect Bottom Track data. The [BK command](#) configures how often water track pings are sent. The number of Water Track pings per ensemble is dependent on the [BP-command](#) (bottom pings per ensemble) and this command setting. Water track pinging is activated from the [BL command](#). Use the BL command to set the location of the Water Track ping.

Required Conditions for Water Tracking

Water Track ping output data is available when both the BK (Water-Mass Layer Mode) and BP (Bottom-Track Pings per Ensemble) instrument settings are nonzero values. The bottom must be at least the Minimum Layer Size + Near Layer Boundary + 20% of the reported depth away from the transducer. The Far boundary cannot exceed 80% of the range-to-bottom of the beam with the shortest altitude. If the bottom comes up so that the Far boundary does not meet this requirement, then the Far boundary is automatically adjusted to ensure this requirement is met, unless the minimum layer size cannot be maintained, in which case the water track ping is skipped and the data is marked bad.

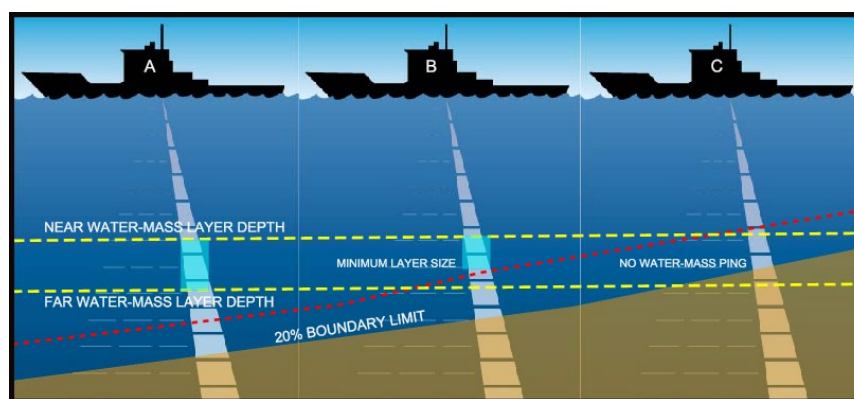


Figure 14. Water-Mass Layer Processing

Water Tracking Parameters

The parameters for DVL Water Tracking feature is either preset in the instrument default mode or user defined (see the [BK command](#) and Table 21, page 110). The user-defined Water Track ping 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 Track ping layer comes within 20% of the boundary (Figure 14, B), the layer compresses in size until the minimum water-mass layer size is reached. No Water Track ping will be sent when the boundary exceeds the 20% limit (Figure 14, C).



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

Current Profiling

The Pathfinder DVL has optional firmware configurations that enable the instruments to measure current velocities in the water column. The DVL, as with all TRDI ADCPs, measures current by dividing the velocity profile into uniform segments called depth cells (depth cells are often called bins). Each depth cell is comparable to a single current meter. Therefore, a DVL velocity profile is like a string of current meters uniformly spaced on a mooring (Figure 15). Thus, we can make the following definitions by analogy:

Depth cell size = distance between current meters. Number of depth cells = number of current meters

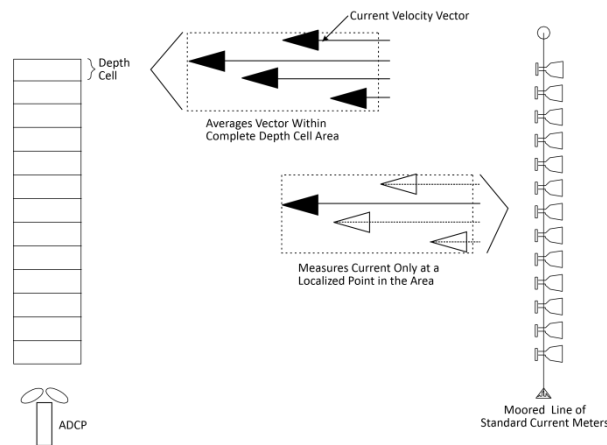


Figure 15. DVL Depth Cells for Current Measurements

The water profile data used for current measurements includes the four different kinds of standard profile data shown below. These data types can be incorporated to varying degrees, depending on the user requirements and mission.

- **Velocity** – as measured from the Doppler shift of the individual beams of the DVL/ADCP.
- **Echo intensity** – A byproduct of the ADCP system. Sometimes used to measure relative sediment, plankton or other suspended particle quantities.
- **Correlation** – an indicator of the fidelity of the ping echo, used for QA.
- **Percent good** – percent of pings that meet specified quality thresholds used for QA.

Beam Coordinate Systems

The Pathfinder 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 16). When you look at the face of the transducer head, the transducers are labeled clockwise in the order, 3-1-4-2 (see Figure 17, page 30). 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.

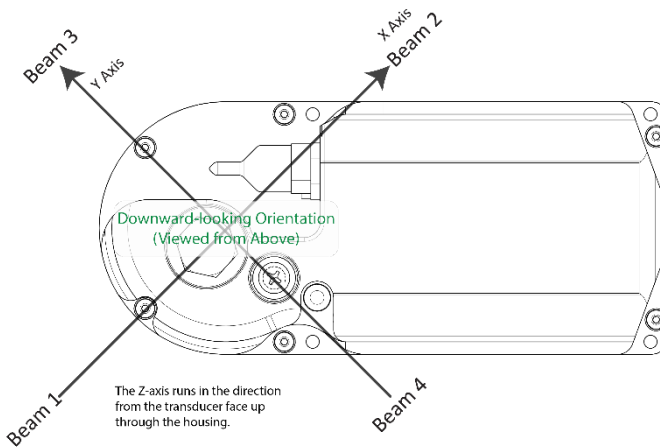


Figure 16. X, Y, and Z Velocities (ROV version shown)

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 PD0 High Resolution Bottom Track and 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.

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).

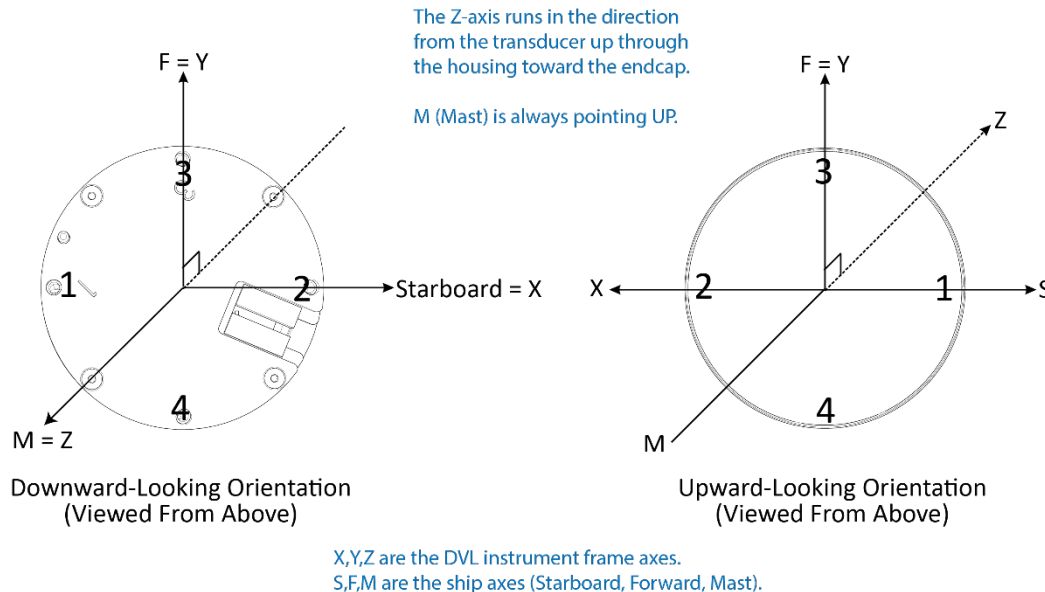


Figure 17. Pathfinder Ship Coordinates (OEM Transducer Shown)

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 18). One can use the Ship Frame and the alignment commands to align the DVL Ship axis with the vehicle/platform Ship axis. See [Mechanical Integration Considerations](#) for more information, and see the [EA](#) and [EP](#) commands. In addition if Tilts are fed to the DVL then the DVL Ship Frame is then Level.

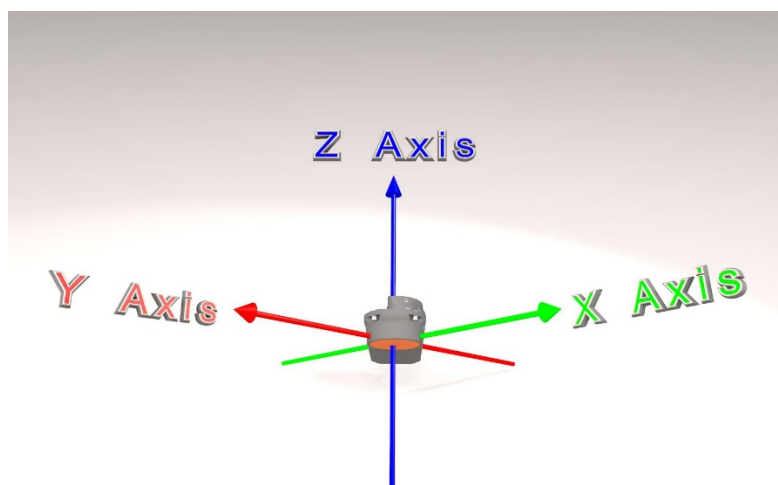


Figure 18. Pathfinder Pitch and Roll

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	+	-

DVL Performance and Influencing Factors

Long Term Performance

TRDI specifies the long-term velocity error of its DVL products as a combination of a percentage of speed (known as “scale factor error”) and an offset (e.g., $\pm 0.3\% \pm 0.2$ cm/s for the Pathfinder 600 kHz bottom track measurement). The water- and bottom-track versions have the same form but may have somewhat different values. For water track, the first term scales with the speed through the water (the magnitude of the vector difference between current and boat velocity). For bottom track, it scales with the magnitude of the boat velocity over the bottom.

Almost all known bias mechanisms (other than rounding error) in DVLs approach zero as the speed approaches zero, although it is difficult to demonstrate this empirically. (Note that when the speed is exactly zero, frozen short-term error can look like bias.) The offset specification term should not be interpreted as the standard deviation of the bias at zero velocity, but rather as a way of accommodating non-linear behavior such as biases that oscillate with velocity or that give an increased scale factor bias at low velocity.

The long-term error is also known as systematic error or bias. If we assume that the predictable component of the long-term error has been subtracted out, then the long-term error can be considered to have zero mean, although it may be non-stationary, in which case the mean may not exist. An example of a bias that can be subtracted out is the beam pointing error, which can be removed using a calibrated beam-to-instrument transformation matrix. A calibration always leaves some small residual uncertainty, which can be considered to be another source of long-term error.

When measuring velocity, the bias represents a small error. When using these velocities for navigation the bias errors will accumulate and the total error will grow over time. This bias error can be mitigated using various approaches; TRDI can offer application support in this area.

Bottom Track

The most important source of long-term bottom track error is the beam angle error. TRDI measures this error and provides a beam correction matrix that reduces this error to within the system’s specified accuracy. Improvements in both scale factor and azimuth errors can be made by doing a more extensive calibration on the platform.

The bottom track velocity measurement is proportional to the speed of sound in water. Any error in the sound speed used in the DVL’s internal signal processing (for example errors in the temperature reading or salinity setting) propagates directly into scale factor error. Therefore, it is important to program an accurate salinity into the unit (the DVL has a temperature sensor). Another approach to minimizing sound speed is to incorporate a speed-of-sound sensor. This external reading of the speed of sound can be sent to the DVL, or the DVL’s sound speed can be set to a constant value and then post-processed to correct the data for the actual sound speed in the navigation system software. For most applications, setting the salinity accurately and using the DVL’s integrated temperature sensor is sufficient to yield highly accurate readings.

Water Track

Water Track accuracy is susceptible to the same error sources outlined above. The first term for long-term accuracy is determined only by the uncertainty of the beam angles, which is the same for water profile, water track, and bottom track. Thus, one can use the same Long Term accuracy as presented for Bottom Track above for water profile and water track. When using the Water Layer mode one must also be aware of the water movement, i.e. currents will be an additional source of error.

Short Term Performance

Short-term errors are random errors with short correlation times that quickly average to zero. They are characterized by the standard deviation. The short-term error in each beam is independent of that in every other beam. Except at very slow speeds, the short-term error in each ping is independent of that of every other ping. The correlation distances at very slow speeds are not accurately known. As the name indicates, the short-term error will reduce the accuracy of instantaneous velocity readings but over larger intervals of time, these errors will not affect the average velocity reading or navigation.

Bottom Track

The standard deviation of the bottom track velocity measurement varies with altitude and can vary with velocity. The default modes have two primary sub modes, one for shallow water at low speed ([Bottom Mode 8](#)) and one for other cases (Bottom Mode 9).

The Pathfinder standard deviation performance depends on altitude. It generally decreases as the altitude gets greater and increases as the altitude gets lower. At the lower altitudes, it increases inversely with altitude. Below these altitudes, the systems attempt to change modes and if successful, the standard deviation drops considerably as the Pathfinder flies below its deep switching altitude and then again when it flies below its shallow switching altitudes.

Water Track

The standard deviation of the velocity measurement for Water Layer will vary as the size of the Water Layer varies – see the descriptions for the [#BL command](#) to determine the Water Layer size and the following equation:

$$\text{Std. Dev.} = \frac{\text{Std. Dev. shown}}{\sqrt{\frac{\text{Water Layer Size}}{10 \text{ meters}}}}$$

Pathfinder DVLs have the capability to compute velocities off of a water track layer while Bottom Tracking. The commands for controlling this mode are [#BK](#) & [#BL](#) for Pathfinder DVLs. However, there are some important consequences of enabling this mode that will be discussed.

First, the time required to complete a ping is significantly increased because two separate and independent pings are involved. TRDI does not currently have ping time models for the Water Track ping. If required, the times would have to be obtained experimentally.

Secondly, there is the opportunity for ping-to-ping interference when the Water Track is enabled. After transmitting an acoustic pulse, the Pathfinder DVLs open their receivers and listen for a return (either from the bottom for a Bottom Track ping or from the water column for a Water Track ping). The return MUST be from the particular ping that is transmitted. If it is from a previous ping, interference results and the system might not work at all, or worse, might give erroneous results.

For example, on a Bottom Track ping, a return from the bottom from the previous Water Track ping might look like the return from the Bottom Track ping, but at the wrong altitude. The problem is usually worse when using Water Track and the previous Bottom Track ping is the cause of the interference. The return from the Bottom Track ping is usually much larger than that from water scattering and when the operating altitude is low, that return can make several round trips from the bottom to water surface to the bottom again and still be large enough to cause interference with the Water Track ping. TRDI recommends that the time between pings be set so that there is enough time for each ping to travel four round trips to the bottom and back when the altitude is significantly less than the specified operating altitude. This time can be calculated by doubling the altitude and then dividing by the Cosine of the Janus angle (normally 30°) and then dividing by the speed-of-sound and multiplying by four.

$$\text{Minimum Ping Time} = 8 \cdot \frac{\text{altitude}}{\cos(J) \cdot \text{SoS}}$$

When operating at altitudes approaching the altitude capability of the DVL, the ping time should be:

Minimum Ping Time > 1.5 times the round trip time at the maximum specified operating altitude.

The long-term and short-term accuracy characteristics of the Water Track mode are discussed in the respective accuracy sections of this document.

Altitude Performance

The altitude (distance above the bottom) capability of TRDI DVL's is influenced by:

- Bottom type
- The average temperature and salinity of the water column from the DVL to the bottom
- The voltage supplied to the system
- The attitude of the DVL
- Bottom slope

TRDI specifies this altitude capability for:

- A typical bottom type being level
- A temperature of 5° C, a salinity of 35ppt
- An input voltage of 24v for Pathfinder DVLs
- ±5° vehicle pitch or roll

Changes in these values will affect the altitude capability as discussed below.

Bottom Type & Slope

Robert J. Urick (3rd edition, 1983) shows curves of backscatter strength vs. bottom type, frequency, and grazing angle. This analysis shows that the scattering strength of bottoms can vary from approximately -10dB for bottoms of "sand and rock" to -40dB for "muddy" bottoms. A higher value (less negative) of backscatter strength means that the reflected signal from the bottom is larger and that the DVL will operate to greater altitudes. TRDI uses a reasonably conservative value of -28dB for the prediction of a DVL's altitude performance. While our experience shows that this works in most environments, bottoms that are "bright" (some rocks and/or gravel) will allow the DVL to operate to higher altitudes while bottoms that are "dull" (mud) will limit operation to somewhat lower altitudes than are specified. In general, a 1dB change in backscatter strength will affect the altitude capability of a DVL by approximately 4m and 2m for 300 kHz and 600 kHz Pathfinders respectively. Larger (less negative) values increase the altitude capability. Bottom slope also strongly affects the return.

Temperature & Salinity

The transmitted acoustic pulse from a DVL is attenuated as a function of range due to a phenomenon called absorption. Absorption is caused by the conversion of some of the transmitted acoustic energy being converted to heat while traveling through the water. This lowers the available energy for the detection and processing of the reflected pulse from the bottom and affects the DVL's altitude capability. This absorption loss is influenced through complex physics by the frequency and the average temperature and salinity of the water column.

The 600 kHz systems are minimally affected by temperature and salinity changes. The 300 kHz system is slightly affected by an increase in temperature and salinity. Warmer temperatures continue to degrade its performance. Operation in fresh water enhances a DVL's altitude capability; in general low-salinity waters will increase the operating range of the unit.

Pitch & Roll

The distance to the bottom of a transmitted pulse for a given beam is a function of the angle of the beam to the vertical. As the vehicle pitches and rolls, this angle can be different for the four beams. Some beams will have further to travel and others will have less. The bottom slope has similar effects. The transmitted energy density of the bottom track pulse is attenuated as it travels through the water column and the further it has to travel, the smaller the energy that is left for detection. As a result, the altitude capability of a DVL may be reduced by the effects of bottom slope, pitch, and roll.

Transmit Power

The altitude capability of a DVL will vary as the input voltage to the system varies. Table 9 below gives an approximation of the range versus battery voltage.

Table 10. Pathfinder Nominal Voltage versus Bottom Tracking Range with Ethernet

Vin V	Idle current mA	Idle Power W	Peak Current mA	Peak Power W	Average Power W	(estimate) XMIT Power W/Beam	BT Range (m)
10	170	1.70	445	4.45	1.95	0.16	74
12	144	1.73	498	5.98	2.11	0.29	77
16	108	1.73	576	9.22	2.40	0.63	82
20	88	1.76	618	12.36	2.71	1.6	86
24	74	1.78	664	15.94	3.05	1.8	89
30	64	1.92	750	22.50	3.77	2.9	92
32	62	1.98	785	25.12	4.07	3.3	93
36	58	2.09	857	30.85	4.68	4.5	95

Slant Range Performance

The accuracy of the altitude measurement of TRDI DVL's is not specified but has been shown to be less influenced by environmental factors. It is important to know that the systems do not measure the altitude by using a beam that is directed straight down as an altimeter might do. Rather, they measure the "slant range" along the four narrow beams that are at an angle to the vertical (normally 30°). In doing this, they measure the time it takes for the transmitted pulse to travel to the bottom, be reflected, and travel back to the instrument. This time is then multiplied by the speed of sound that either the user enters or is computed from the temperature and salinity data that the instrument has. The "slant range" is then projected into the vertical by multiplying by the Cosine of the Janus angle (normally 30°). Naturally, each beam's measurement of this "slant range" will change as the environment changes. These changes include vehicle attitude (pitch and roll), bottom slope, and changes in the speed of sound. The next sections discuss the errors that these environmental changes cause. This is followed by a brief discussion of the additional, improved outputs that the Pathfinder DVLs provide.

Speed of Sound Variation

As the speed of sound changes through the water column either due to temperature or salinity changes, the time it takes for the round-trip travel time changes. For example, a decrease in sound speed will cause an increase in travel time and the instrument (not knowing about the change in sound speed) will interpret this as a longer "slant-range". A somewhat mitigating effect is that the beams will refract as the sound speed changes. For example, a decrease in sound speed will refract the beam towards the vertical

which decreases the distance the pulse has to travel and this partly offsets the change in travel time. This error is difficult to calculate because one needs to know the actual speed of sound profile in the water column. A couple of examples are given below:

Example 1: A linearly changing temperature from 15°C at the instrument to 4°C at 250m depth will cause the “slant range” measurement to read high by about 1% at an altitude of 250 meters.

Example 2: A step change in temperature of 10°C at a depth of 50 meters will increase the “slant range” measurement a little less than 1% when operating at 100m altitude.

Bottom Slope

Pathfinder DVLs multiply the measured “slant range” of each beam by the Cosine of the Janus angle (normally 30°) to indicate the vertical distance. While a simple solution is to average the four beam values obtained for altitude, this is not the preferred method. The equation for this is shown as (1) below. This is reasonably accurate when there is no bottom slope, but a better algorithm is shown in (2) below for bottoms that are sloped.

$$h \approx \frac{h_1 + h_2 + h_3 + h_4}{4} \quad (1)$$

$$h = \frac{1}{\frac{1}{h_1} + \frac{1}{h_2}} + \frac{1}{\frac{1}{h_3} + \frac{1}{h_4}} = \frac{h_1 h_2}{h_1 + h_2} + \frac{h_3 h_4}{h_3 + h_4} \quad (2)$$

Where h is the altitude and the h_1, h_2, h_3, h_4 are the four beam “slant ranges” projected into the vertical. This equation is exact if the bottom is a plane surface.

Pitch & Roll

Pitch and/or roll of the instrument causes the h components shown in (1) above to change. Because it is complicated to compute the h components for all combinations of pitch, roll, and bottom slope, the worst-case relative error as calculated by equation (1) above is used and is approximately:

$$\frac{\Delta h}{h} \approx 1 + \frac{1}{2} \phi^2 \pm \beta \phi - \frac{1}{2} \beta^2 \tan^2 \theta$$

where β is the bottom slope in radians,
 ϕ is the instrument tilt in radians, and
 θ is the beam Janus angle.

This method is used in the case that tilts and bottom slope are in the same direction. Note that the error is second order in the bottom slope and tilt parameters. An 8-degree tilt will cause the simple four-beam average to be 1% long. A 14-degree bottom slope will cause it to be 1% short (when the beam Janus angle is 30°).

Resolution

The Pathfinder DVLs provide two additional altitude outputs in the [Bottom Track Range Format](#). The first is called “Slant Range” which is actually a range to the bottom in the Z-axis. It is a combination of the four slant ranges per equation (2) above. The second is called “Vertical Range” where the instrument pitch and roll are used to calculate the altitude. This is the most accurate output for altitude since it compensates for the orientation of the instrument.

Mechanical Integration Considerations

Alignment

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

TRDI recommends mounting the transducer head with Beam 3 (instrument Y-axis) rotated 45° relative to the ship forward axis (Figure 19). 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 Pathfinder's effective velocity range by a factor of 1.4. If Beam 3 is aligned at an angle other than zero, use the EA command to describe the rotation between instrument Y axis (beam 3) and ship forward axis. Refer to [EA - Heading Alignment](#).

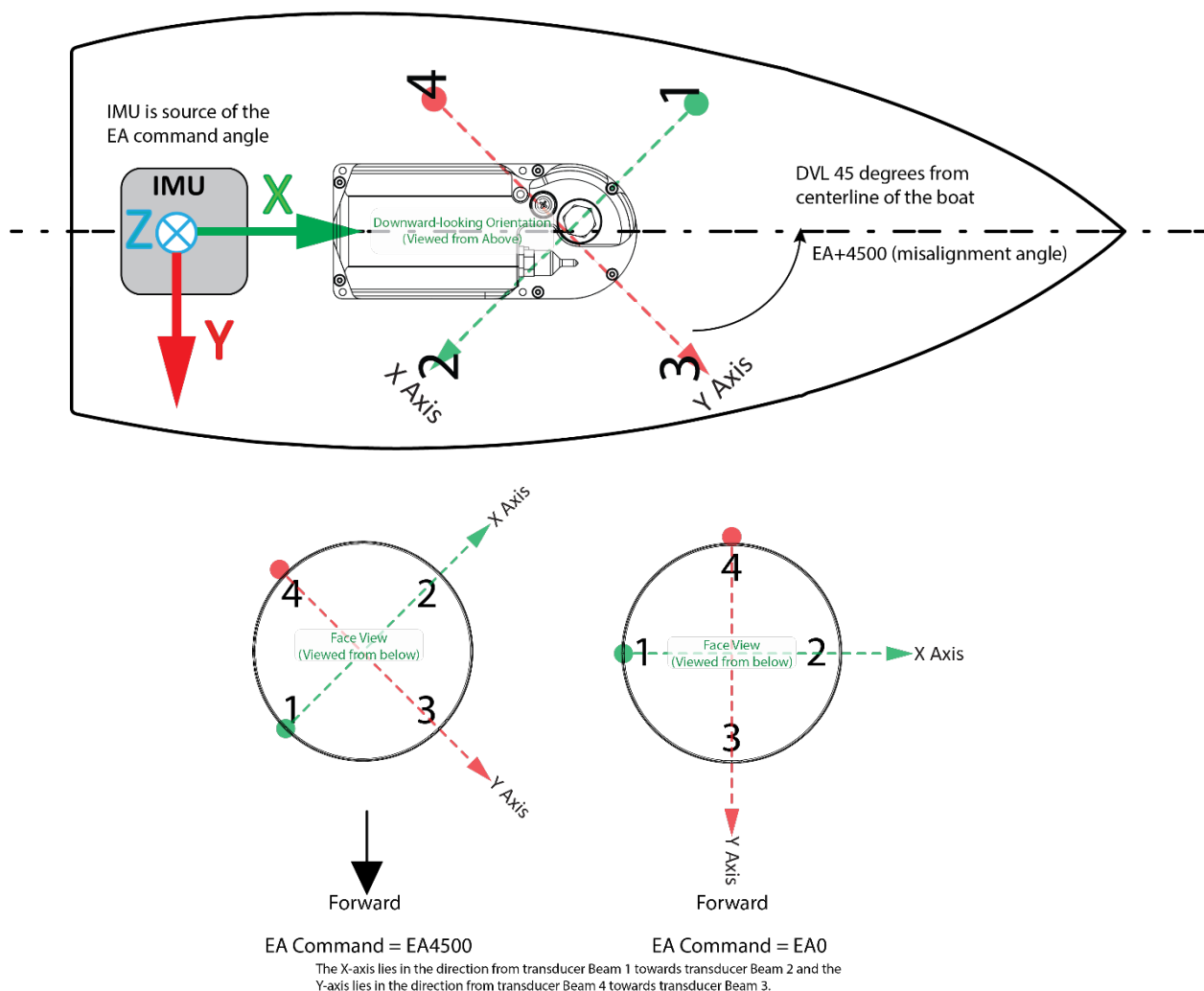


Figure 19. Transducer Alignment Reference Points

Beam Clearance

Acoustic obstacles such as cables, hull, other instruments, etc. are numerous on undersea vehicles. Special care should be observed in clearing the DVL beams of any acoustic obstacles. A 90 degree cone around the face of the transducer should be observed to account for each beam acoustic spread. This Beam clearance should be observed when Bottom Tracking, Water Tracking and Water Profiling. Any acoustic obstacle in the Main Beam and acoustic spread will interfere with the DVL measurement or worse prevent the measurement altogether. If the DVL is used near a quay wall for instance, then a quick rule of thumb is that for every meter of vertical separation between the DVL face and the seabed the same separation is necessary between the DVL and the Quay wall. DVL transducers also have side lobes, which could collect energy backscattered by acoustic obstacles in the beam clearance cone as shown in the [outline installation drawings](#). This is mostly critical when performing Water Tracking or Water Profiling.

Mounting the Instrument

There are many options for mounting the Pathfinder systems and they depend on the application. Use the four mounting holes on the transducer (ROV version only). See the [Outline Installation Drawings](#) for dimensions and weights.

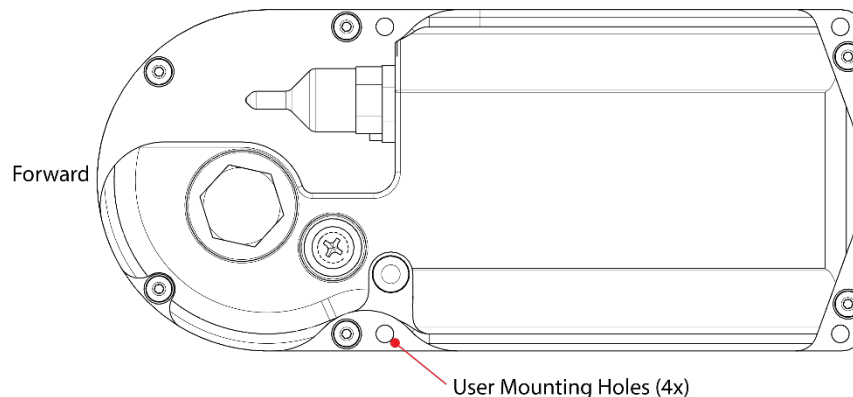


Figure 20. End-Cap view of the transducer showing mounting holes



Your Pathfinder DVL transducer housing is made of aluminum that is protected by sacrificial anodes and a hard anodize coat and paint. **Do not connect other metal to the DVL.** Other metals may cause corrosion damage.

Use M6 isolating bushings and washers when mounting the DVL to a metal structure. Keep this in mind when fabricating a fixture, which materials to use, or deciding how to place it on the vehicle.

Pitch & Roll

Pitch and Roll should be limited to avoid a beam pointing vertically toward the bottom. The Pathfinder DVL beams are slanted 30 degrees from the DVL vertical axes. This beam angle was selected as the best trade-off between velocity accuracy, resolution and acoustic energy throughout the water column (which is greater for greater smaller angles).

Moreover, a DVL can only measure velocity relative to itself by measuring the Doppler shift along each beam. If a DVL beam were to be pointing vertically towards the sea bottom then it would be unable to measure the Doppler effect of a DVL motion parallel to the sea bottom. Therefore, the DVL should never be tilted 30 degrees so that a beam would be pointing vertically at the medium of reference, i.e. sea bottom or ice.

Use the ship's roll and pitch reference to mount the transducer head aligned with the ship axes as closely as possible. If the instrument x and y axes are not in the same plane as the ship forward and starboard axes, then use the #EI (see [EI - Roll Misalignment Angle](#)) and #EJ (see [EJ - Pitch Misalignment Angle](#)) commands to align them.



If the transducer is not level, and no Tilts are fed to the DVL using the #EP command, then Water Profile bin-mapping will be incorrect. Large misalignments can cause large velocity measurement errors.

Routing Cables

Use care when routing cables 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 cables.

Route cables so:

- Cable does not have kinks or sharp bends. The cable bend radius is 4.5 inches.
- Protect the cable with hose if zip-ties are used to secure it to structures (see Figure 21).
- The Pathfinder cable (or junction box, if one is used) must **NOT** be exposed or installed next to high voltage lines or circuits, motors or engines.
- If a junction box is used, make sure that all of the cable conductors are connected properly and avoid ground loop effects. Make sure that the conductors are electrically isolated from each other.
- Cable can easily be replaced if it fails.



Figure 21. Do not use Zip-Ties Directly on Cables



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

Electrical Integration Considerations

Grounding Issues

Multiple grounds connected to a vehicle hull or to a vehicle chassis can have undesirable consequences. Grounding problems can be avoided by implementing prudent grounding schemes.

The DVL has three isolated grounds in order to achieve the desired performance levels of the instrument. The grounding systems are as follows:

- Communication ground
- Power ground
- Chassis ground

The grounded systems noted are isolated from each other. The Power Ground is isolated from the Chassis Ground by an isolation / ground noise filter circuit. This 'link' between these two grounds is susceptible to EMI from outside sources if the isolation is not properly maintained outside the DVL. If the DVL's isolation / ground noise filter circuit is shorted, the DVL may experience an increased noise floor, ultimately propagating into the signal receivers.

This same isolation circuit will be shorted if the chassis (DVL GND) is in direct contact with the vehicle chassis (vehicle GND) and the Power supply ground connected to the DVL is also connected to the vehicle chassis (vehicle GND).

Typically, the DVL chassis is anodized, thereby providing electrical insulation when the instrument is mounted into what are usually metal hulls. The anodized coating is required to maintain chassis ground isolation.

Another potential electrical path bypassing the isolation/ground filter can occur through seawater. The current generated can pass via the DVL anode, (or scratches in the DVL coating), through the seawater, and then back to the hull (or frame) to the vehicle. The likelihood of this ground path occurring is increased if the hull of the vehicle is connected to the Power ground of the DVL through the vehicle's grounding circuitry. Typically, this resistance is very high resulting in only a few microamperes of current and is limited by the size of the DVL anode and the distance between the Anode and the grounded hull of the vehicle (the greater the separation the greater the resistance).

For the condition described, if the exposed surface resistance is great, the DVL will not be adversely affected, as is usually the case. For conditions where the surface resistance of the DVL chassis and vehicle are low, undesired interferences will occur.

Another way that you can have undesired grounding of the DVL to the frame or hull of a vehicle is that mounting holes can lose their anodized coating by scraping of the anodized inner wall with the mounting screws. The use of an isolation plate and plastic bushings and washers are good practices to avoid this grounding path.

In summary, bypassing or shorting the DVL isolation / ground noise filter circuit will increase the sensitivity of the DVL to vehicle noise, which will increase noise floor in the instrument and in the data, thereby resulting in a reduced operational range and data contamination from interference. Additionally, bypassing of the DVL isolation/ground filter can lead to accelerated corrosion.



Your Pathfinder DVL transducer housing is made of aluminum that is protected by sacrificial anodes and a hard anodize coat and paint. **Do not connect other metal to the DVL.** Other metals may cause corrosion damage.

Use M6 isolating bushings and washers when mounting the DVL to a metal structure. Keep this in mind when fabricating a fixture, which materials to use, or deciding how to place it on the vehicle.



A direct connection to the Pathfinder OEMD electronics shield or transducer head potential will reduce the ground isolation voltage from approximately 500VDC+ to 60VDC. If maintaining 500VDC of ground isolation is required, then TRDI recommends connecting the shield of the Pathfinder electronics to the vehicle chassis through a 1000VDC 0.01uF capacitor.

If 60VDC of ground isolation is acceptable, then the Pathfinder OEM shield may be directly connected to the vehicle chassis.

Electrical and Grounding Testing Best Practices

Suggested steps to verify possible ground leakage of the Pathfinder DVL:

1. Turn your Power Supply output to OFF.
2. Connect the standard power connections from the Pathfinder cable to your power supply (24-volt typical but could be anywhere in Pathfinder supply range).
3. Connect a single, 2ft +/-10% long, 22-gauge, wire to the - terminal of the Independent 12-volt supply or battery.
4. Add a 10K to 62kohm (+10%, 1/4W) resistor in series with this wire
5. Connect the other end of this wire (you can use an alligator clip) to one of the Anodes.
6. Connect the + of the Independent power supply or battery to the – PWR of your Pathfinder i.e. also Neutral of your Power Supply (see figure below).

The goal is to create a -12-volt EMF relative to the ground of the standard DVL supply. Then use the -12 volts to check the leakage current through a kΩ resistor.

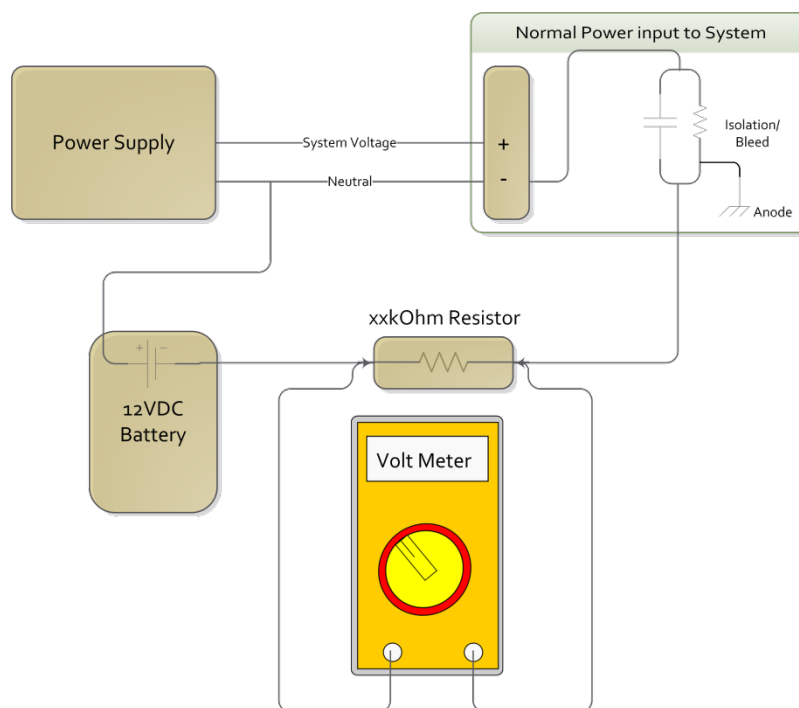


Figure 22. Ground Fault Current Check

7. After all the connections are made, turn the voltage supply output ON.

8. Assure that the DVL system is awake via *TRDI Toolz*.
9. After 30 seconds, measure the voltage across the resistor.
10. Apply the following equations to find the isolation impedance.

$$R_{Isolation / Bleed} = \frac{V_{battery} - V_r}{I_{leak}}$$

$$I_{leak} = \frac{V_r}{R}$$

Where V_r is the voltage across the resistor and $V_{battery} = 12V$ in our example.

11. The impedance noted should be $32M\Omega$ at $32V$.



Do not short the housing to any grounded surface (such as an ESD mat) or water tank while conducting this part of the test. Otherwise you create a ground short, and leakage current will rise above the acceptable limit, indicating a false failure.

Electro-Magnetic Interference (EMI)

The main sources of EMI are induced voltages from signal and power lines that are located in proximity to the effected component or signal. These problems are avoided or minimized by the proper routing of wires, proper shielding of wires and proper location of individual systems components. EMI is also caused by unwanted differences in potential on signal or ground electronic lines as is discussed below.

EMI Coupling Through Cables

A remote head DVL is susceptible to interference along the length of the cable connecting the DVL to the receiver located in the electronics chassis. Interference signals injected into or adjacent to the remote head cables may be increased in voltage more than 100,000 times due to the gains of the internal amplifiers. It is critical that to route all DVL cables such that they are not in proximity to interfering signal sources, such as clocks, CPU's, DC-DC converters, engine controls, and hydroelectric power units, power lines, acoustic devices and their power electronic. In the case of radiated EMI to the cables, then the EMI can be rapidly reduced as the power reduction goes by square of the separation distance between the source and the DVL cables. It is recommended that detailed bench trials be conducted on all cabling configurations before implementing this configuration into the operational platform. For more information, see the [Built-In Tests](#) such as PT200.

Power Consumption

The reference for the average electrical power in Watts used by the Pathfinder is that which occurs at the maximum pinging rate and maximum altitude for Pathfinder systems are:

System Type	Average Power	Input Voltage
Pathfinder 600 kHz Without Ethernet	2.35W @ 9% ping duty cycle	24V
Pathfinder 600 kHz With Ethernet	3.25W @ 9% ping duty cycle	24V

It should also be noted that there is a constant background power consumption of 1 watts without Ethernet and 1.9W with Ethernet for the processing electronics as long as the Pathfinder is not in the “sleep mode”, aka Idle Power.

The average power consumption depends upon the transmit duty cycle.

Inrush Currents

The DVL power supply must be specified with consideration to the instrument inrush current. The inrush current inherent to the DVL is due to the current required to fully charge the front-end internal electronics capacitors. The capacitors store and then provide power on demand during the DVL transmit phase of operation. The maximum inrush current of two amps is only seen on initial instrument startup and is required to provide the initial capacitor charge.

It is essential that the power supply used to power the Pathfinder be of sufficient capacity to meet the startup inrush and operational current demands described.

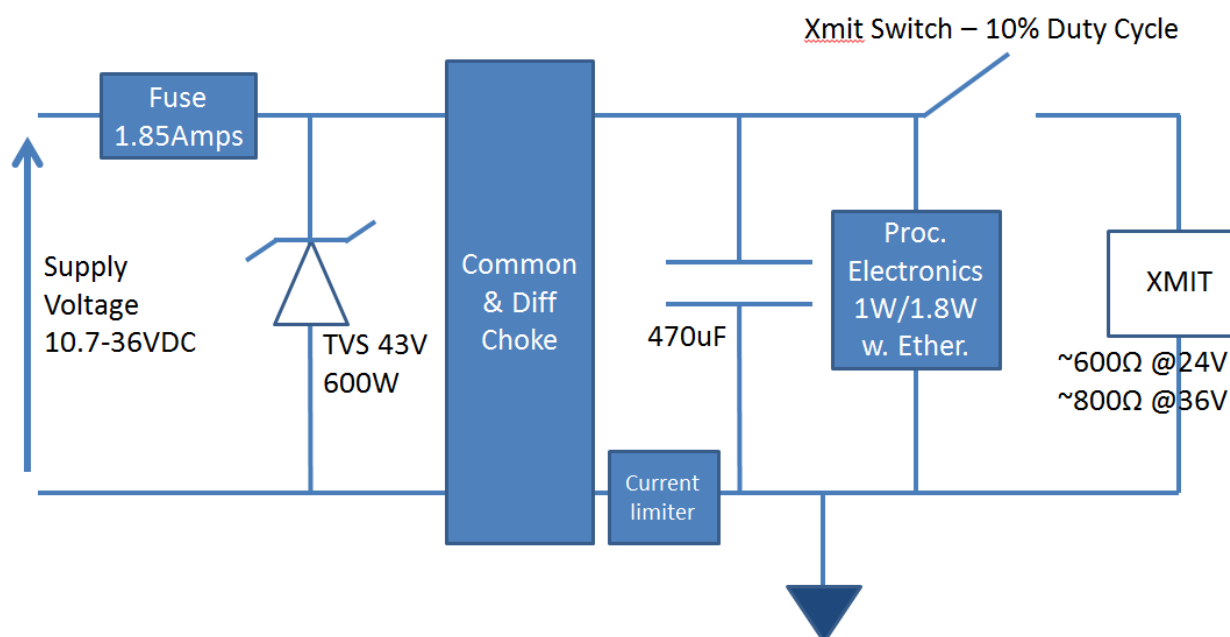


Figure 23. Pathfinder Power Circuit

Acoustic Integration Considerations

Flow Noise

Water flowing over the transducer faces increases the acoustic noise level, which in turn decreases the operational range of the DVL. Flow noise can be reduced across the transducer faces by mounting the DVL behind a sea chest, fairing, or acoustic window. Flow noise can also be reduced by optimizing the transducer head type and design to conform to the platform hull form being used. Optimized transformer heads can be custom made by Teledyne RD Instruments for specialized applications and may exist as commercial off the shelf product for more standard applications.

Cavitation

Cavitation is the formation of air bubbles due to the reduction of ambient pressure because of hydrodynamic flow conditions. Cavitation at the edges of the transducer or surrounding area near the transducer often results in increased acoustic noise, and a corresponding reduction in operating range. As with flow noise, cavitation can also be reduced by optimizing the transducer head type and design to the platform hull form being used.

Ringling

Definition: Ringing occurs in DVLs when the energy from the side lobes of the transmitted signal excites the metal portion of the DVL transducer such that a resonant condition occurs. This causes the transducer and anything attached to it to resonate at the system's transmit frequency. While some ringing is normal in DVLs its magnitude must be minimized.

It is helpful to review the transmitted acoustic signal associated with DVLs in order to fully characterize the phenomenon of ringing. The DVL transmits an acoustic pulse into the water. The main lobe of this pulse bounces off of the sea bottom (bottom track) or particles in the water column (water track) and the signals returned from these particles are used to calculate the velocity of the water.

Along with the main lobe of the transmitted pulse are many associated side lobes. It is these side lobes that come in contact with metal the housing of the DVL transducer and as noted above are the source of the ringing.

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

All DVLs "ring" for some amount of time. Therefore, each DVL requires a blanking period (time of no data processing) to keep from processing the ringing energy. During this time the transmitted pulse is traveling away from the DVL at the speed of sound, so this "blanking period" corresponds to a range near the DVL that cannot be profiled. Each DVL frequency has a different typical ringing duration.

These typical ringing values are recommended as the minimum setting for all DVLs using default setups (minimum value for the blanking period as set by the [#BB command](#) and [#WF command](#)).

It should be noted, on some installations the effects of ringing will last longer than the recommended settings above.

Mounting Considerations

Well Mounting: 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 acoustic 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 using the [WF command](#) and for Bottom Track using the [BB command](#).

To mitigate the effects of ringing inside the transducer well, a sound absorbing material can be mated with a mounting plate or a clamp to reduce acoustic coupling increasing the ringing period. Also, the inside walls of the well can be lined with a sound absorbing material to damp the ringing effect. Using standard neoprene wet suit material has been found to work well.

Windows Use Considerations

Windows can be used to produce overall performance improvements in vessel-mounted DVLs. 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.
- 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.

Disadvantages

- The range of the DVL may 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”. This will cause the data being collected during the ringing to be biased. Some vessels have reported a loss in range as great as 50 meters. As noted, 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).
- The transmit signal could be reflected off the window and back into the other beams.

If the well has excessive ringing (due to reflection from the window or ringing within the mechanical structure itself) the DVL can be instructed to keep from processing this signal. To do this, the blanking period of the instrument would have to be increased. This is possible for Water Profile using the [WF command](#) and for Bottom Track using the [BB command](#).

Temperature differentials should also be considered because 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

Recommended Practices for Window Use

Window Orientation: The acoustic window should be flat and parallel to the transducer face. Note this is not an absolute requirement but a tilted or curved acoustic window can make the transducer susceptible to differentials in the water temperature.

Window Material: Our experience has shown that Polycarbonate is very good for use as an acoustic window. The speed of sound of polycarbonate is approximately 2423 m/s. That makes a quarter lambda 0.99mm at 614.4 kHz, so the recommended thickness would be 0.5 to 0.75mm. If this is too thin to support the weight of the water inside the well then it would be better to use 0.5 lambda, rather than being exactly at a quarter (being too close to a quarter lambda will cause a strong reflection). This would be 1.97mm at 614 kHz and 3.94mm at 307 kHz.

The thickness of the Polycarbonate material depends on the frequency you intend to use and the weight of the water inside the window as noted above. Table 11 is provided as a guide for choosing the maximum thickness window to use. If additional thickness is still required due to the weight of the water in dry dock, then increase the thickness in increments of $\frac{1}{2}$ lambda. Be warned that increasing the thickness beyond the values listed in Table 11 can degrade the performance such that the system will no longer meet the performance specifications as listed in [Chapter 6 - Specifications](#). Increase window thickness at your own risk.

Table 11. Maximum Window Thickness

Frequency	Thickness
614.4 kHz	2mm
307.2 kHz	4mm



One concern with window selection is that it has 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 while you are either filling/drainning the dry dock area.

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 1cm. Never allow the transducer to touch the window. If installed farther than 1cm, then it is imperative to ensure that the window aperture is large enough to clear the beams. The farther away the transducer is from the window, the more the sound is reflected off one beam and then reflected into another beam.

Acoustically-absorbing well lining: A sound absorbing material should be used inside the well to minimize the effects of sound ringing within the well. The recommend material for both 300 and 600 kHz systems is Precision Acoustics F48 anechoic tile.

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

SONAR Interference Considerations

Interference from other acoustic and electromagnetic devices can cause velocity and direction bias. In extreme cases, interference may prevent the DVL from operating. It is possible to avoid interference by using a suitable triggering scheme. This is particularly recommended if the other device is operating within the bandwidth of our DVL receiver (in some cases up to 40% of the carrier frequency of the DVL) or if the other device has a harmonic component that is within the DVL frequency receive bandwidth. Initiating a well-conceived triggering scheme (triggering the interfering device, the DVL, or both) will keep the interfering device from operating during the DVL's transmit and receive period. It is important to note that the TRDI receivers have 90 to 110 dB of gain, which for the sake of clarity is greater than 100,000 times of voltage amplification.

Coded Signal Theory Review

In the default bottom track Broadband mode, the DVL transmits two acoustic pulses composed of a series of coded sequences. The acoustic signal transmitted into the water is composed of a series of elements, where each element consists of 16 carrier cycles. The frequency spectrum of this signal is a $\sin(x)/x$ function centered at the carrier frequency, with a -3dB bandwidth of 6.25% of the carrier frequency. As a result, any nearby sonar equipment which is sensitive to this frequency range will receive interference from the DVL transmit pulses.

TRDI DVL transducers are manufactured with the ability to transmit and receive more than the required 6.25%. Any other sonar emissions in this frequency range will potentially be received by the DVL and interfere with its operation. The following table summarizes the transmit and receive bandwidth for each frequency available for the Pathfinder DVL systems:

Table 12: Transmit and Receive for Pathfinder DVLs

System	Carrier Frequency	Transmit & Receive Bandwidth
600 kHz	614400 Hz	38.4 kHz (6.25%)

Interference Detection and Mitigation

TRDI has several tools to detect and mitigate interference. One of these is a FFT software program (see [Identifying EMI](#)) that in function turns the DVL into a semi real time Fourier spectrum software analyzer. Another technique for interference detection is the use of very long water profiles.

FFT can be useful in catching continuous interference. However, its sampling is dependent on the number of FFT samples selected by the user. It may therefore update too slowly to detect an intermittent acoustic interference source. On the other hand, the long water profile may detect interference from an intermittent source as it listens for a longer period, although this method may not be effective for detecting self-interference or continuous low level source interference. When using the water profiling technique to identify interference, the user must monitor both RSSI and Correlation in order to distinguish external interference from the DVL's own echo signal.

If interference is present from another device on the vessel, the most efficient mitigation technique is to use a triggering scheme to coordinate their operation. For example, an external trigger commands the external device and the DVL to alternate their transmissions, and this external synchronization ensures that the two devices will never interfere with each other.

Reference, Data & Timing Considerations

Coordinate Frames

As described in [Beam Coordinate Systems](#), a DVL can output the measured velocity vector in one of the following coordinate frames: beam, instrument, ship, leveled-ship, and geographic (“earth”) frames. The distinction between instrument and ship frames is that the latter takes into account intentional alignment angles such as the azimuth angle of Beam 3 relative to the fore-aft axes of the vehicle. The coordinate frame may be selected.

There are two main advantages to using instrument or ship coordinates. First, if the instrument has been calibrated so that the beam-to-instrument transformation matrix contains instrument-specific corrections for beam pointing errors, then these corrections will have already been applied by the DVL firmware. Second, it is easier to measure and account for separate horizontal and vertical scale factor errors if the velocity is already in instrument or ship coordinates. For the majority of applications instrument or ship coordinates will be the optimum solution.

For more advanced applications, the instrument can output velocity in beam coordinates. The advantage of using beam coordinates is that beam velocities are the fundamental quantities that the Pathfinder measures. Even if only one beam is able to give a valid measurement, it can still provide useful information whereas a minimum of three valid beams are necessary for measurements in other coordinate frames. Using this technique an external transformation would have to be performed to obtain velocity in instrument or earth coordinates. The beam-to-instrument transformation matrix can be extracted from the Pathfinder using the &V command.

Data Screening

Pathfinder measurements suffer from occasional data outliers which, although rare, can still be far more frequent than would be expected from a normal (Gaussian) probability function. To prevent the navigation system from giving undue weight to data outliers, it is important to screen the Pathfinder data to detect and reject them.

Data outliers are often the result of ambient data environmental factors. The Pathfinder DVLs have several internal routines to detect and account for the false data described. Unless the bottom is detectable and the correlation value is above a threshold criterion, bottom track velocity will be marked bad (0x8000 which equates to the full-scale negative value of -32768 decimal). The presence of fish in one or more beams will also cause data outliers. The Pathfinder also can screen for fish using the information in the intensity data for all four beams.

For operations in coordinate frames other than beam coordinates, if all four beams pass these screening tests, the Error Velocity (representing the redundant information among the four beam velocities) is calculated and its magnitude compared to a threshold as an additional screen. Measurements exceeding this Error Velocity threshold will be rejected. When using beam coordinates this velocity screening is not done by the Pathfinder firmware. It can however, be performed outside the Pathfinder.

To keep the Pathfinder errors as independent as possible from ping to ping, the Pathfinder does not screen for unreasonably abrupt changes in altitude or velocity. These kinds of screens are most appropriately performed at the front end of a navigation system. An isolated abrupt change in altitude is most likely an outlier (fish or other false target) that should be rejected, whereas a step function with a persistent final altitude might be real (a cliff or a transition from a ship hull to the real bottom, for example). A robust algorithm will reject the isolated data outlier while quickly recovering from a persistent step. Similar screening can be done on velocities.

Three-Beam Solution

The default operation of DVL's requires all four beams to be tracking and providing good data. When this occurs, the instrument screens the velocity data by comparing the magnitude of the Error Velocity to a commanded threshold. The Error Velocity has redundant information among the four beam velocities. This is done for all coordinate systems other than Beam. A three-beam solution is produced if, on a particular ping, only three beams have good data, and in that case only, error velocity screening cannot be performed. When three-beam solutions are enabled, the DVL still computes a four-beam solution with error velocity screening on all pings where all four beams have good data. There are operating circumstances where due to the bottom slope and/or pitch only three beams are able to have adequate reflection from the bottom, while the fourth beam is not. The three-beam solution makes it possible to operate in such severe environments.

Ping Timing

It is usually desirable to minimize the time it takes a Pathfinder to complete a ping cycle because this enables faster data update rates. It is important to note that using the Water Layer Track in addition to the Bottom Track mode significantly lowers the update rate of the Bottom Track data because there is an extra ping(s) between Bottom Track pings. Therefore it is recommended that the Water Layer mode be commanded off when the Altitude is well within the Altitude capability of the Bottom Track (Bottom Track is providing good data).

When the maximum operating altitude is known, the [BX command](#) can be used to limit the maximum ping time in Bottom Track mode, since time to receive data from the bottom is proportional to the distance to the bottom.

For example, a 600 kHz Pathfinder has a default BX altitude of 110 meters. If the user knows that the altitude will never exceed 50 meters, he can set the BX command to 50 meters and then when operating at 50 meters it potentially reduces the search time required to reacquire the bottom after bottom lock has been lost, because it bypasses the search pings that look for greater altitudes. Therefore, if BX is set to 50 meters, and if the DVL is operating at 50 meters altitude, and loses the bottom, then the search algorithm will not look at 110 meters if it does not find the bottom at 50 meters, and will only search at altitudes up to 50 meters, which may result in a faster reacquisition.

Table 13 shows the approximate Bottom Track ping times for a Pathfinder DVL as a function of altitude above the bottom. The data is for the case where there are no external sensors being used:

Table 13: Approximate Bottom Track Ping Times (in milliseconds)

Altitude in meters	Ping Time in ms
3	110

The following equation provides an estimate for the time between pings for ranges greater than 3.8m for the 600 kHz:

$$\text{Ping time (seconds)} = \text{RTB} \times 3.8\text{e-}3 + 40\text{e-}3$$

Where RTB is the Range to Bottom in meters.

System Synchronization

Typically, data from the Pathfinder is fed into a larger user supplied acquisition and control system, which collects data from other sources as well. In such situations, it is important to have all the data accurately referenced to a common time base.

The Pathfinder data ensembles in PDO format contain a time stamp having a resolution of 10 ms that is from a reading of the real-time clock before the ping. This time stamp is of limited utility because it is difficult to keep the Pathfinder clock synchronized to the navigation system clock and also because

the 10 ms resolution is arguably too coarse when the Pathfinder is combined with an INS. It is recommended instead that synchronization be achieved using a hardware trigger (CX1 or CX2 command) with the data time-tagged with the navigation system time recorded at the time of the hardware trigger. Care must be taken so that the time tag represents the correct edge of the trigger and that the time tag be attached to the correct data ensemble, because the data ensemble arrives after the next ping has been triggered.

Note that the minimum time interval between pings (which is the maximum velocity update rate) is altitude dependent, thus the triggering scheme should be tested over the full working range of altitudes (including an altitude beyond bottom track range). These tests should be made with water mass layer measurement both on and off.

INS Integration

The Pathfinder is integrated into the vehicle and connected to its network. The user accesses the Pathfinder's configuration HTML page and navigates to the network configuration page. The network configuration page provides a selection of PD outputs and a network configuration for each. The web page automatically refreshes and displays the current setting.

Network Settings

Network Configuration	STATIC	Link Status Active
Base IP Address	192.168.1.100	
Network Mask	255.255.255.0	
Gateway Address	192.168.1.1	
Name Server Address	192.168.1.1	
Command/Control Port	1033	

Output Formats

FORMAT	ENABLE	PROTOCOL	ADDRESS	PORT
PD0	ON	UDP	192.168.1.255	1001
PD4	OFF	UDP	10.20.230.23	1035
PD5	OFF	TCP	10.20.230.1	1036
PD6	OFF	TCP	10.20.230.1	1037
PD11	OFF	TCP	10.20.230.1	1038
PD13	OFF	TCP	10.20.230.1	1039
PD26	OFF	TCP	10.20.230.1	1040

Submit Reset

1. Configure the Pathfinder to output PD0 via UDP broadcast socket 255:255:255:255, port 1001.
2. The command file used by the Pathfinder enables Ethernet turnkey mode, and sets the delay start time to 30 seconds (CT command set to CT 2 30) (see [Creating or Modifying Command Files](#)).
3. Cycle power to the Pathfinder (wait 30 seconds between power off and power on) and monitor the output via Wireshark. The user can also command the DVL to start (as an alternative to waiting for Turn Key timeout) by sending a [CS command](#) to the DVL TCP Command and Control Port (192.168.1.100, port 1033).
4. 30 seconds after application of power the UDP broadcast packets from the Pathfinder are observed. Use *TRDI Toolz* to see that the DVL is outputting the Broadcast UDP data (255.255.255.255: port 1001).

5. The [Bottom-Track High Resolution Velocity](#) (5803h) and [Navigation Parameters Data](#) (2013h) blocks provide aid in the velocity measurement resolution and quality information for use in an Extended Kalman Filter (EKF) Inertial Navigation System (INS) solution. Time Of Validity output for highly accurate coupling with an INS further improves your resulting DVL aided INS position accuracy. See the [Navigation Parameters Data Format](#), bytes 54-69.
 - The Figure of Merit (FOM) is calculated for every velocity estimate and each beam
 - Estimates the standard velocity error
 - Confidence that when FOM is low, error is low
 - FOM can provide warning for individual beams, not entire velocity solution
 - May be used to filter data to reduce standard deviation and bias

Operational and Setup Considerations

Unfavorable Environments

There are certain environmental conditions where the DVL's errors may be large or where the instrument does not function at all.

- In the surf zone where waves are actively breaking, the acoustic beams may not be able to penetrate the bubble clouds, and even if they do, the sound speed may be significantly affected by the high concentration of bubbles. This changes the Doppler scale factor.
- The dense growth of weeds or kelp on the bottom may prevent the DVL from detecting the true bottom. If the DVL locks onto the top of the weeds by mistake, they may have motion relative to the bottom due to wave action, which would give inaccurate velocity measurements.
- In areas of high salinity (>35ppt), the absorption of the sound by the water column will reduce the altitude capability of the DVL. Absorption (maximum range) can also be affected by water temperature, as outlined in [Temperature & Salinity](#).
- In areas where the salinity varies as a function of location and/or time, the Doppler scale factor will be varying and it may be necessary to integrate a speed-of-sound sensor into the navigation system to keep the velocity measurement errors to an acceptable value. Temperature gradients can cause similar issues, as outlined in [Speed of Sound Variation](#). This is only for the Z-axis velocity, as SoS does not impact 2D velocities on a Phased Array Transducer.

Triggering

There are two methods for triggering the DVL:

Sending ASCII Character through Serial Port. When the system is interfaced to a serial port (e.g. a navigation computer), the system can be setup to wait for an input before each ping. To setup the DVL in this fashion, clear the Auto Ping Cycle bit in the [CF command](#) by sending CFx0xxx, where the x's represent the settings of the other parameters. 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.

Using Low-Latency Triggering. The trigger methods shown above all have latencies ranging from a few milliseconds to a few hundred milliseconds, which may be excessive for high-precision applications. Consequently, TRDI has developed a low-latency trigger method (see [CX command](#)). To configure the DVL for low-latency triggering, set the CX command to enable trigger input. Start the DVL pinging with the CS command. The DVL will then wait for a trigger before each ping. Setting the trigger lines to a

break state for no less than 10 microseconds sends the trigger. The DVL will then ping within 1 millisecond of the leading edge of the break pulse. Note that it is possible through the CX command settings to set a timeout for the DVL to wait for a Trigger and then shall no Trigger occur during that time it will either Self Deploy and never look for Trigger again or Ping once and then go back to waiting for Trigger. The input trigger voltage is 3.3VDC to 7VDC.

Design Considerations & Bench Test

To avoid problems when the DVL is installed in the final system, it is helpful to perform a bench test prior to installation. In the bench test, the DVL should be exercised along with all the other components that will be installed in the final system. By performing this initial bench test EMI and acoustic interference issues can be identified and remedied while all the system components are easily accessible.

The recommended types of systems that should be bench tested are described below.

1. If possible, select components and systems that are acoustically, and RF wise “out of band”, based on the specifications from the manufacturer of that equipment.
2. It is important to test for all EMI interference that may be occurring in the system. Bench test all of the equipment in air, and see if there are interfering sources by using the FFT tool (refer to [Identifying EMI](#) for instructions on it use), after which you can plan the shielding and grounding strategy.
3. Spread out the various systems and components that you intend to use on the bench in a pattern similar to how they will work.
4. While observing the FFT use the DVL as a “probe” and pass the DVL over live components (including hydraulic actuators) you intend to use in your design. Identify any unacceptable interference.
5. While observing the FFT use the DVL as a “probe” and touch it against components or systems to check their acoustic signature. Identify any unacceptable interference.
6. Try varying bench test temperatures, so it can be determined if there are tank circuits in your system that “tunes into” our band, or visa-versa.

Troubleshooting

The purpose of this section is to provide a list of critical tests to perform when the system is not operating to either specifications or expectations. Additionally, this procedure will also provide a step by step guide to configuration of the TRDI DVL to record all available data for troubleshooting with TRDI support. The information acquired from these procedures will allow the user to solve many encountered technical problems. Should assistance from TRDI be required, the information acquired will greatly expedite our analysis and service provided.

Communications Issues

Follow the steps in [Connecting to the Pathfinder](#). If you have problems communicating with the Pathfinder check to make sure that you are selecting the right COM port, baud rate, parity (none), stop bits (1), flow control (none).



Windows is finicky when it comes to USB to serial adapters. Most adapters that TRDI tried did not work. One adapter that works well is <http://www.easysync-ltd.com/product/527/es-u-1001-r100.html>. Possibly any device with FTDI drivers and devices will also work.

Initial Shakedown Deployment

Troubleshooting Checklist

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

Identify Unit

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

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

The returns from these commands will provide the unit Firmware version, the system operating frequency, beam matrix information and verify that the electronics are working as expected.

Run Built-In Tests

If something FAILED in the PA test, repeat the test several times rotating the unit by 90 degrees for each test. By doing so, it may be determined that the failure is directional and most likely due to external environment. Please be sure to log the results by pressing <F3> if using *TRDI Toolz* to communicate with the system.

Failures might be observed IF:

- Other magnetic or acoustic devices or high current system are in the vicinity of the unit,
- The Pathfinder DVL is exposed to electrical interference such as that from other acoustic devices or SONARs or other electronic devices (i.e. cellphones, radios, computers, TV's, etc.).

- The Pathfinder DVL or its cable is exposed or installed near potential sources of EMI's such as high voltage lines like main engine cables, galley equipment, winches, engine room equipment, cranes, high voltage lighting circuit, etc.
- Oftentimes, a noisy (i.e. non-UPS) power supply could cause failures in this test as well.

Strategy if Failure is found in the BIT tests:

- Power down these devices and remove or move the suspect systems at least three meters away during diagnostic testing.
- Re-run the PT300 command and log the data for about 30 seconds to 1 minute.
- Modify the log file by adding a note as of what has been done prior to a PT300 test such as: "Turning 300KHz Sonar off" for instance.



Always run the PA test with unit transducer beams submerged in water. **The test may fail in air and if so, is not relevant.** Only a failure with the transducer at a minimum in contact with water is a relevant test.

If possible, run at least one PA test on the deployment site.

Provide Unit Setup

Provide a text file with the commands sent to the unit during deployment – Pre- or Suffix it:

Script_File_[Vehicle_or Deployment_Name_and/or Date&Time_Goes_Here].txt

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

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

For example, the bottom track group of commands for a Pathfinder DVL:

```
>b?
Available Commands:

BA 024 ----- Amplitude Threshold [0..255]
BB 0030 ----- Blanking distance (cm)
BC 220 ----- Correlation Threshold [0..255]
BE 1000 ----- Error Velocity Threshold [0-9999mm/s]
BF 00000 ----- Depth Guess [0=Auto, 1=MaxAlt dm]
BH 105,180 ----- Gain Switch Threshold (0-255cnts:lo;hi)
BI 025 ----- Gain Switch Altitude (meters)
BJ 100000000 ----- Data Out {t;c;*;h;r;n;*;*}
BK 0 ----- WMass Mode [0=off 1=WB 2=LostB 3=W]
BL 160, 320, 480 ----- WMass Params [min, near, far (dm)]
BM 8 ----- Bottom Mode [8 & 9]
BN 0,999 ----- Speed Log Hold/Drop Control
BO 025 ----- Distance Accum. Filter Tau (1/100ths)
BP 1 ----- Number of BT Pings in ensemble [0-999]
BQ -32768 ----- Set outvel when over range limit (mm/s)
BS ----- Clear Distance Traveled
BX 02750 ----- Max Depth (dm)
BY 20 ----- Transmit Length (pct)
B? ----- Display B-Command Menu
```

Describe Deployment Environment & Operational Conditions

It is important to document the deployment environment of the test or mission that has occurred. The following parameters are important:

- Location
- Water description
- Bottom Type – topography and bottom type
- Depth
- Sediment conditions
- Temperatures
- Salinity
- Proximity to ocean structures or acoustic reflectors
- Speed through water

Describe the System Installation

Provide a description of your vehicle, and more specifically 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.).

Provide Raw Data & Describe Issue for Analysis by TRDI

- Describe the performance issue or problem.
- Recover the raw data from your instrument. This will preferably be done in the PDO output format. The information will be sent to TRDI with the complete deployment data if it is not possible to provide PDO data please identify the data format in which the data was collected.
- Provide screenshots or ensemble numbers to locate region(s) showing the unexpected data behavior.

Provide Additional Data for Analysis by TRDI

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 an ASCII Text comma (or other ASCII character) delimited format file. 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 Engineering Data for Analysis by TRDI

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.



If you are already decoding PDO and your decoding algorithm can handle more bytes in each ensemble [engineering data bytes] then you can record this Engineering PDO data into a file for us to review it with our Engineering software suite. It is not mandatory to use the MR1 command to enable recording onto the loop recorder, nor to erase the loop recorder first as described below.

Before new data can be acquired, the recorder has to be erased. This is done by opening a *TRDI Toolz* session (see [Connecting to the Pathfinder](#)) and then send the command **me ErAsE** to your Pathfinder. This will erase the recorder.

Capture the data from the instrument by opening a log file in *TRDI Toolz*. You can do this by clicking the  icon and then entering a filename.

Send the following commands to the unit by copying them to the clipboard of any editor and pasting them into *TRDI Toolz* by typing **Ctrl V**:

```
CR1
BP1
;[set BX value in dm to 20% more than the water column depth]
BX00350
#BK0
EX00010
;[set the EA angle between Beam3 and forward centerline of the vehicle)
EA+13500
CF11110
;Output data format PD0 or #PDx with x different from 0
#PD0
&O1000
&N3FFC
; Turn recorder on
MR1
CK
CS
```

Press enter after the **CS** to start ping.

Alternatively, you can download the commands by saving these into a text file and typing **Control+T** in *TRDI Toolz*. This will open the Script Editor.

It is important to leave the system powered up after the command file is sent; otherwise, the &O and &N commands will be lost (these are not saved in the flash). The ping rate will be very slow because writing the data to the recorder is time consuming. Try not to change depths quickly so the unit won't have trouble keeping up with at the lower ping rate.

After the test, you can download the data off the loop recorder by connecting to the Pathfinder and opening a *TRDI Toolz* session (see [Connecting to the Pathfinder](#)). Then change the baud rate to 115200 by entering the CB811 command. Then select the **Tools** menu and the **Download Data** option of this menu. *TRDI Toolz* will ask you what directory you want to store the data.

The process should be automatic from this point. There should be about 2MB downloaded from the recorder if it was full and it likely will be since the ensemble size is quite large with all the engineering data included. The full data set should be about 92 ensembles. .

As previously mentioned in reference to the PA testing, if other devices are in the vicinity of the unit and are suspected to be the origin of the data quality issue, then those devices should be isolated to the greatest extent possible. It is best to power the device down or remove it from the area (at least 3m) and then re-deploy using either one of the above set-ups. Recover and provide TRDI Field Service with the raw binary (PD0) data.

Identifying EMI

Purpose – Observation of the plots will provide information about interference to the DVL. This will probably NOT help in determining if the DVL emits interfering signals to other devices. The *NGSPFFT* software provides the user with a frequency domain plot (~100% bandwidth) of the Pathfinder's four receiver channels during a sampling interval.



Contact TRDI Field Service for a copy of *NGSPFFT*.

Adjustments – The *NGSPFFT* software has several easy to use adjustments. For example, the **Filter** is a moving average of the last 30 samples; and the **FFT N** is the FFT sample size, with a default of 512. The FFT sample size is directly proportional to the bandwidth of the FFT resolution. Additionally, the **Hardware Bandwidth** and **Hardware Gain** and **System Frequency** can be adjusted. In addition, the communication port number and communication baud rate can be adjusted to match the communication parameters of the Pathfinder.

Operation – The *NGSPFFT* software connects to the Pathfinder DVL using a computer's serial port and sends the Pathfinder DVL a special set of commands. The Pathfinder responds with a stream of digitally processed values, from the receive portion of the circuit and firmware. The sonar transmitter is not used for the FFT, i.e. the FFT routine uses the sonar receive transducer, circuitry and firmware only, not the sonar transmit.

The *NGSPFFT* computer software processes the values it receives from the Pathfinder, and then plots the resulting frequency response in a graphical form for each sonar channel, in terms of RSSI versus Frequency. RSSI is a Teledyne RD Instruments nomenclature for Received Signal Strength Intensity in A/D counts. The frequency span is centered at the carrier frequency (for Pathfinder, this is 614,400 Hz) and spans $\pm 12.5\%$ bandwidth in NB mode, from (for Pathfinder or other 614400 kHz systems this is 308,400 Hz to 921,600 Hz.)

Once the user learns the basics of the FFT software, you can use the Pathfinder cables and transducer as probes by holding them or locating them next to equipment you would like to include in your vehicle (ROV, AUV). The user will see the effect of "in air" interference. If interference is noted, different strategies can be incorporated to mitigate the interference.

For example, separating devices or shielding may be help. Note that the transducer face (where the urethane is on the transducer) will always be submerged in water during real operation. You can simulate this in water performance by placing the transducer at the bottom of a small bucket, with just enough water to wet the urethane faces of the transducers. Often what appears to be interference when the transducer is in air may be completely gone when the transducer is submerged in water. The inverse may be true as well. If there are other sonars or mechanical devices such as hydraulic power units that create acoustic signals, these may interfere with the Pathfinder system and the interference may only be detected when both our transducer and the other device are submerged in a larger bucket or tank of water or somehow acoustically coupled through a hull or structural framework.

Install the NGSPFFT Software – Use the install package. Installation of the *NGSPFFT* software is similar to installing older windows software. After successfully installing the *NGSPFFT* software there will be two folders added to your computer: C:\Program Files\RD Instruments\NGSPFFT and C:\FFT. Inside the second folder, will be a file, C:\FFT\Port.txt that stores the serial COM port number and the baud rate to be used. Please open this text file using Notepad® or similar and edit the two lines. The first line is the COM port number. Change this to number of the COM port your computer will use to talk with the Pathfinder. The second number is the baud rate. Change this to 115200. Then save this file with the changes.

Using NGSPFFT to Identify Interference

Equipment needed:

- A computer with at least one serial communication port from the computer to the Pathfinder's Communication Port 1 (a USB to serial converter works fine).
 - The same computer with *TRDI Toolz* software provided or from the TRDI website.
 - The same computer with the *NGSPFFT* software loaded.
 - A power supply for the Pathfinder (10.7 – 36 volts DC, 1.5A is sufficient).
1. Connect to the Pathfinder using *TRDI Toolz* and change the baud rate to 115200 baud.
 2. Apply power to the Pathfinder 10.7 to 36 Volts DC. Set the current limit to 1.5A for Pathfinder 600.
 3. Connect to the computers comport.
 4. Start the *TRDI Toolz* software and establish communication with the Pathfinder. After sending a "break" you will see something like the following (The firmware version may be different):

```
Pathfinder
Teledyne RD Instruments (c) 2017
All rights reserved.
Firmware Version: 67.xx
>
```

5. Type "CB811" <ENTER> then type "CK" <ENTER> you will see something like:

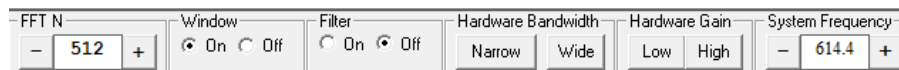
```
>cb811
>ck
[Parameters saved as USER defaults]
```

This sets the baud rate to 115200 and speeds up the FFT data transfer when using the *NGSPFFT* software.

6. Close the *TRDI Toolz.exe* program.
7. Place the transducer into a bucket of water, just deep enough to cover the urethane faces of the four transducers. This will help to properly match the acoustic impedance of the transducer and to reduce interference from radio stations or other nearby RF sources. Later, when the *NGSPFFT* software is running you can remove the transducer from the water and hold it next to a laptop or a computer terminal and see what effect these devices have on the FFT, and hence the DVL.
8. Open the *NGSPFFT.exe* program. The program will immediately attempt to establish communications and send appropriate commands. Within 30 seconds, you should see four plots of the FFT for each of the Pathfinder's receive channels.
9. If no plots are generated, there is no communicating with the Pathfinder. You can select by clicking on the **Comms** menu and select the port that Pathfinder is connected to.
10. Click on **Comms** menu and select the baud rate (115200).
11. If you still don't see any plots after 30 seconds, try cycling the power to the DVL. If that does not help, please exit the *NGSPFFT* software and reopen *TRDI Toolz* and assure the communications are set at CB811 (115200 baud).

Check the Adjustments: At the bottom of the *NGSPFFT* window, assure the following settings:

- FFT N = 512
- Window = On
- Filter = Off
- Click the Hardware Bandwidth button **Narrow**
- Click the Hardware Gain button **High**.
- Click the + / - buttons to set the system frequency.



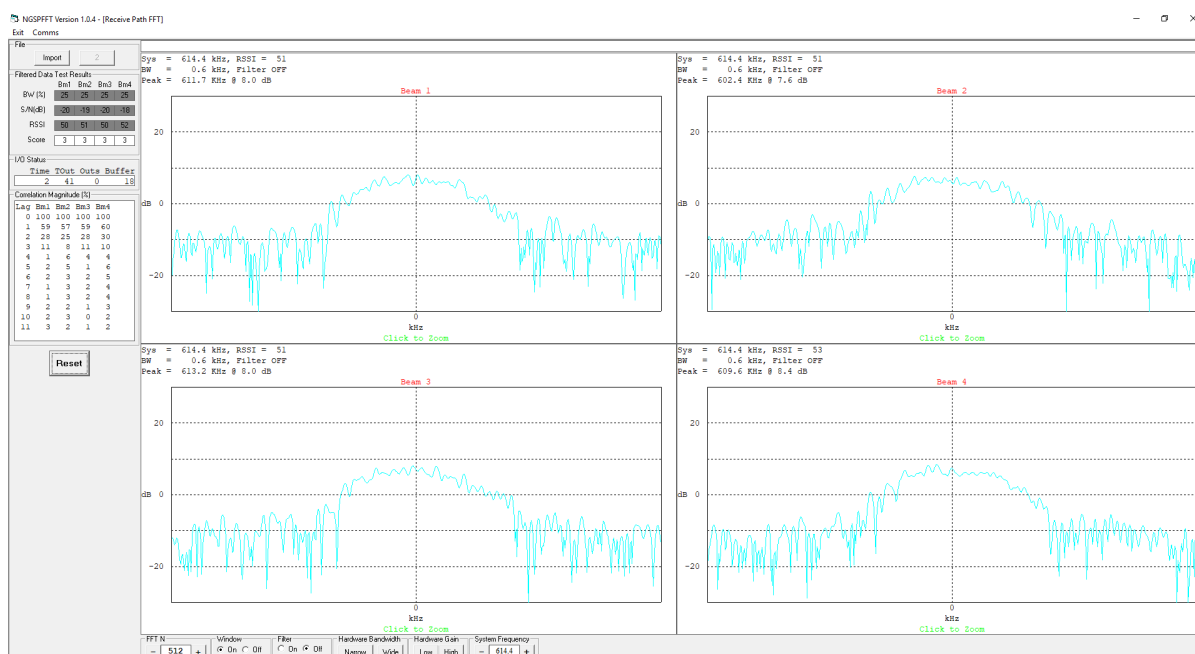
When selecting **Narrow** in *NGSPFFT*, the DVL will select the appropriate filter width for processing the data. If **Wide** is selected, then it is possible that interference terms will show up in the FFT that will not affect the DVL's accuracy.

Zoom: By clicking on the “beam” of interest, you can zoom in to see only that beam. Click again to zoom out.

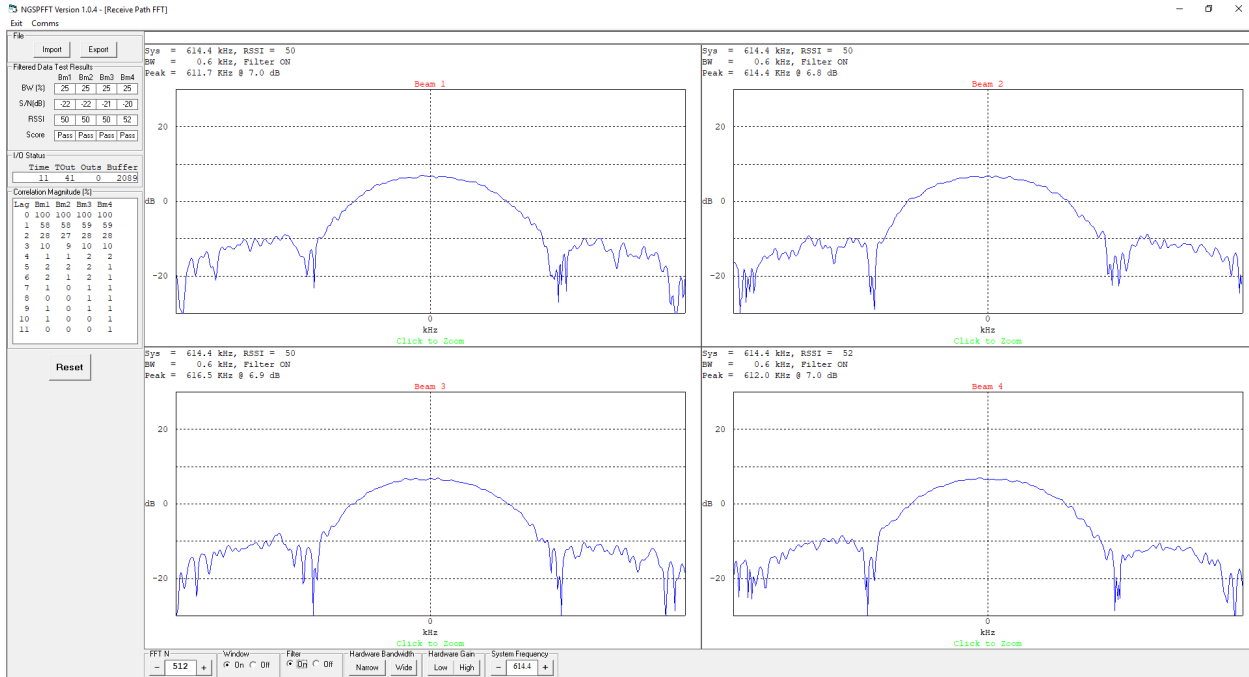
Mouse-Over: By placing the cursor over a frequency of interest, a mouse-over window will appear with more information about that frequency and amplitude.

Examples of Clean FFT Plots, No Interference

The following is a screen shot of a typical “clean”, 512 sample, FFT of a 614,400 kHz system with the **Filter** Off. The bandwidth of the plot is approximately 6.25% of the system frequency FFT in narrowband receiver mode.

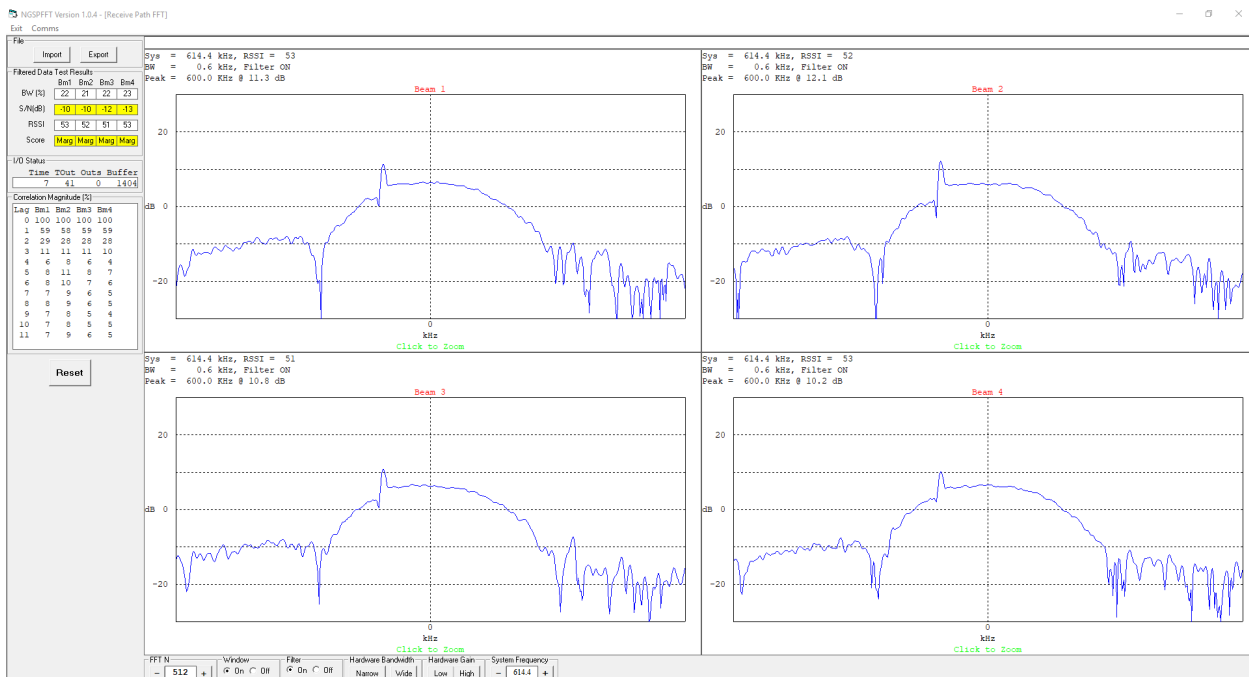


The following is the same “clean”, 512 sample FFT, with the **Filter** On radio button selected. It is simply a moving average of the last 30 FFTs. The color changes from light blue to dark blue once the FFT has acquired an average of the 30 previous (the Score will count down from 30 each time a setting is changed).



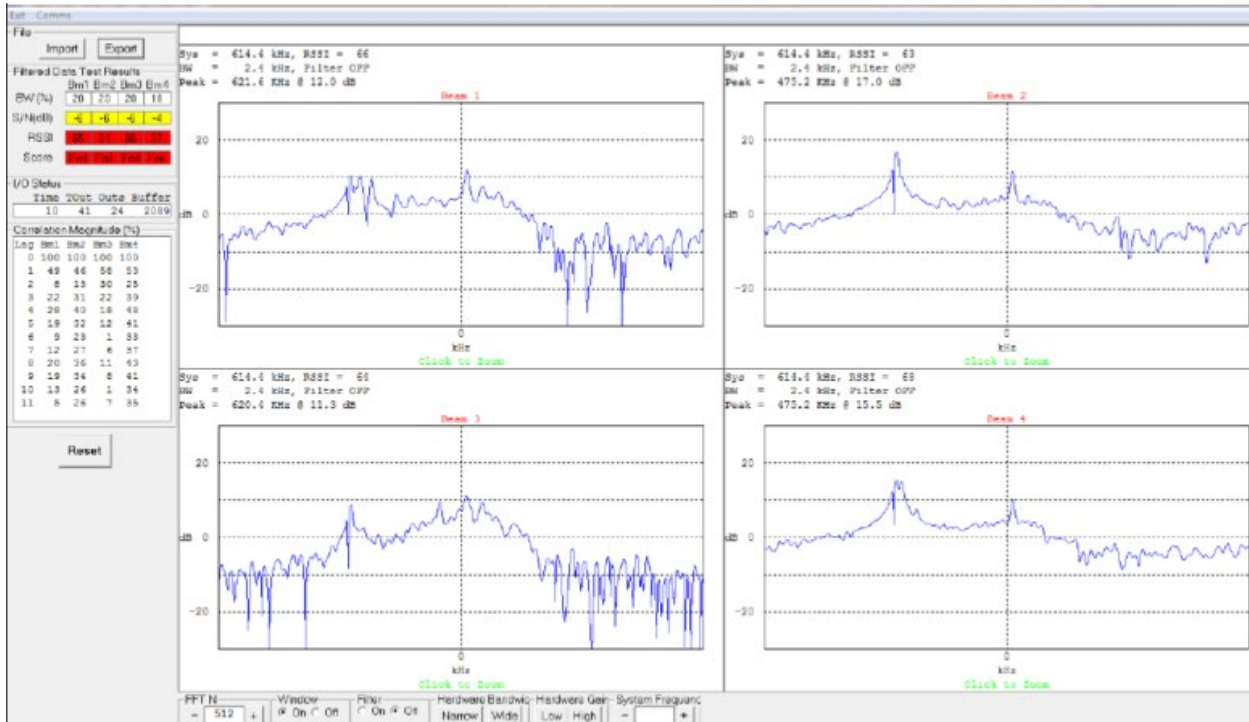
Examples of Interference

The following image shows an interference term on all channels at 601 kHz just to the left of center frequency. Notice the Filtered Data Test Results in the upper left of the screen has a yellow background color indicating Marginal for its score.



Although not ideal, the previous interfering term is small, and the DVL will still bottom track accurately if the bottom echo return amplitude is stronger than this very weak interfering term.

The following types of interference will have significant effects on accuracy of water profiling and bottom track and should cause failures of the Built in Tests. Notice that the filter function is off, and you still clearly see that you have an interference issue, and you can identify the frequency if you Mouse-Over.



Alternative FFT Tool for Virtual Comports

For those applications where the DVL is not directly connectable through a physical RS232 comport, the *NGSPFFT* will unfortunately not be able to run, as it needs a physical UART/comport to be able to send a Serial Break to the Pathfinder DVL to respond and start acquiring the FFTs.

An alternative Tool exists called *QCMon*, which sends a software break instead, i.e. “+++”. The ‘look and feel’ of *QCMon* is only slightly different from the *NGSPFFT*, thus you will find similarities in data provided. You will need to change the way you run it by following these steps instead:

1. In *QCMon*, after you set **Comm > Port** and clicked on the right Baudrate using **Comm > Baudrate**, click on **Comm > BREAK** and you should see the Pathfinder DVL banner as depicted below:

```
Pathfinder DVL
Teledyne RD Instruments (c) 2017
All rights reserved.
Firmware Version: XX.xx
```

>

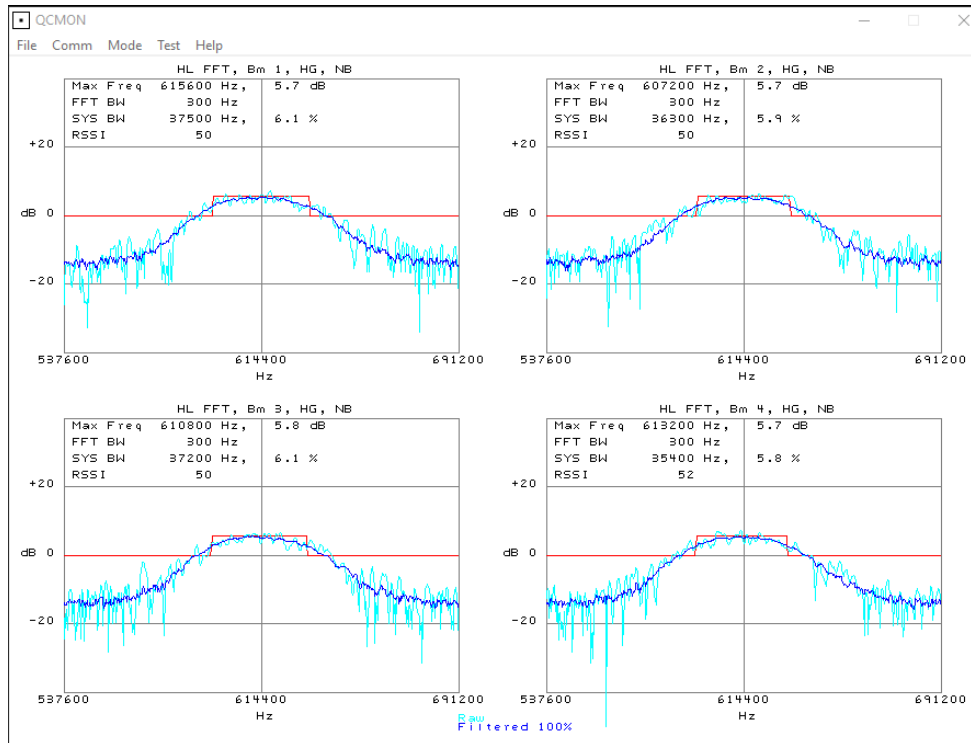
2. Then go to **Comm > Terminal** and then in the *QCMon* window type any commands (B?, TS?, etc.) like you would with *TRDI Toolz* and you should get replies from the Pathfinder.
3. If this is working, send PT200.

```
>pt3
Receive Path Test (Hard Limited):
      H-Gain W-BW      L-Gain W-BW      H-Gain N-BW      L-Gain N-BW
↓
↓
RESULT...PASSED

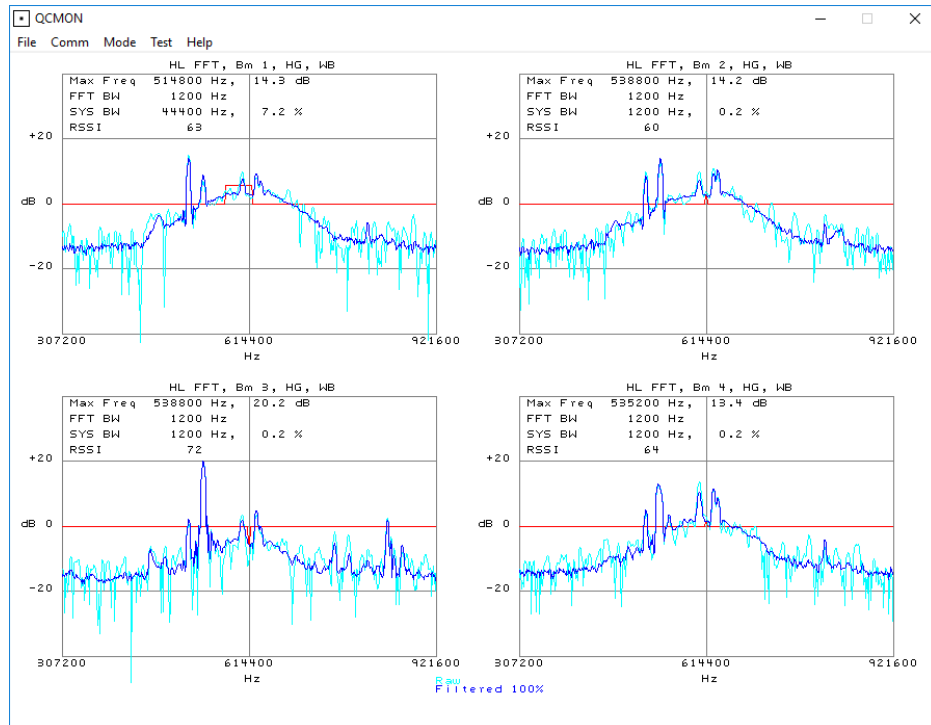
>pt5
Transmit/Receive Continuity Check:
↓
↓
RESULT...PASSED
```

>

4. If all this works up to this point and you have a high baudrate then go to **Test > FFT (HL) > Go** to turn the FFT spectrum analyzer mode on each beam:
 - Anything that looks different in overall shape or spikes anywhere that show on the light blue line (realtime FFT) is of concern even more when it shows on the dark blue line (averaged FFT).
 - Note that you can click on any beam to Zoom on it if this helps.
 - The way to ‘collect’ FFT data with *QCMon* is to take snapshots in different scenarios, such as take one for baseline in water with the vehicle ON but no active sensors, arms, thrusters, (or even using a known cleaner external power source) then take a snapshot for each of the major vehicle components* turned ON to active mode.
 - * anything that is powered on the vehicle and can be placed into an active mode (which usually means either or both driving more current or creating EMI or Acoustic pulses)
 - It is also advised to do the same with the DVL Built-in test and go back to the terminal and send PT200 for each of these scenarios. To do so **Go To Test > STOP** then **Go To Comm > Terminal** and then send PT200. Same as the *FFT*, you will have to take snapshots for each scenario.



Example plot with no interference



Example plot showing interference

Chapter 3

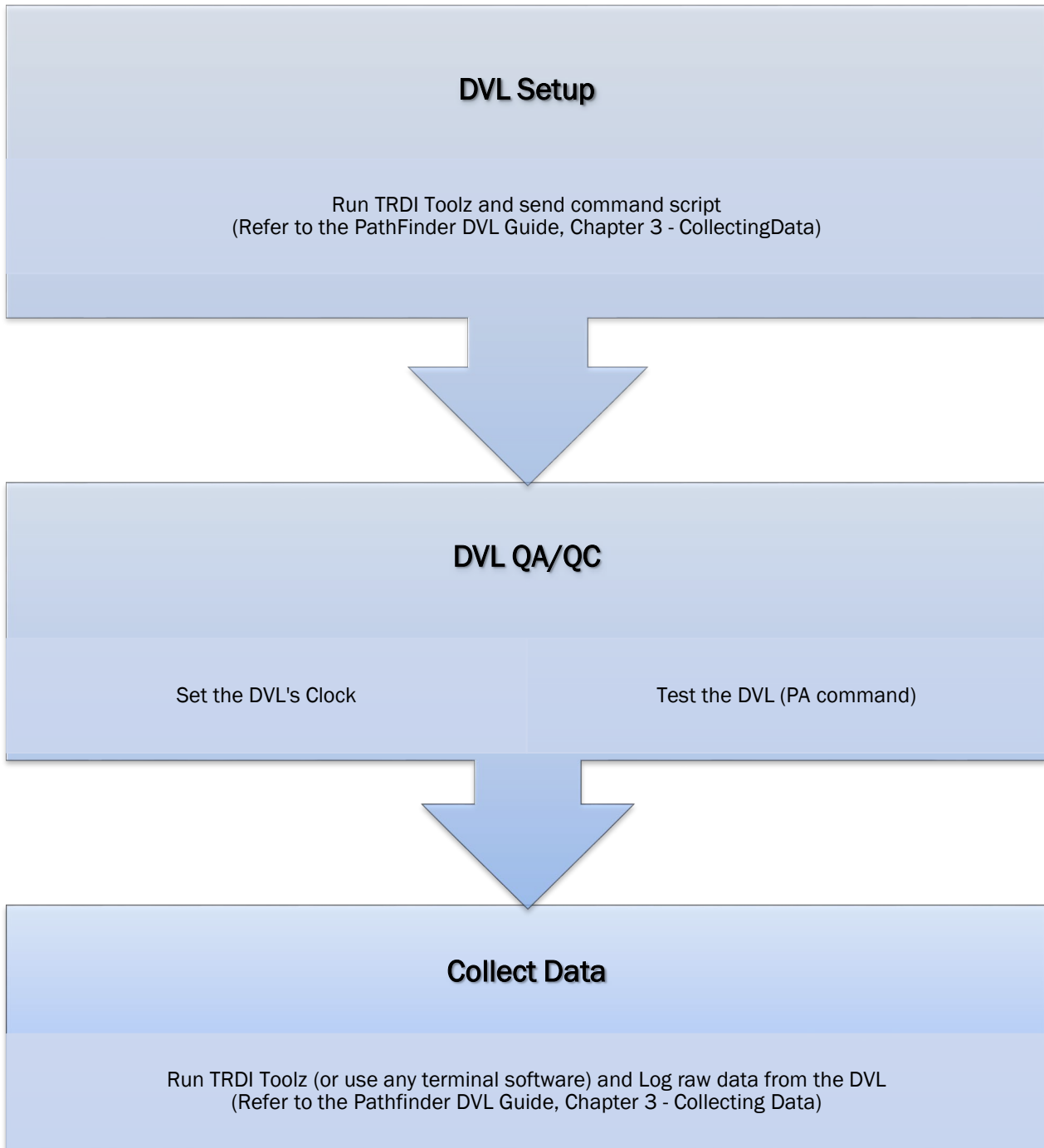
COLLECTING DATA



In this chapter, you will learn:

- PathFinder General Deployment Flow
- Creating or Modifying Command Files
- Sending Commands to the PathFinder

Pathfinder General Deployment Flow



Creating or Modifying Command Files

Command files are simply ASCII files produced by ASCII editors such as *NotePad* that set Pathfinder command parameters. In general, they contain ASCII characters that are sent out through the serial port.

To create a command file:

- Copy the example command file into *NotePad* and edit the commands as needed. Refer to the [Command Descriptions](#) for detailed information on each command.
- If the first character of a line is a semi-colon, then all characters after the semi-colon (including the semi-colon) are ignored. This feature is to provide file comments that the user may insert for clarity.
- Use one command per line.
- Save the file. Command files can have *.rds, *.txt, *.scr, or any other extension as long as they are ASCII text files.



The example command file has comments that explain the function of each command. It is a good idea to keep the comments and edit them when making command changes.

The following shows an example printout of a command file.

```
;-----
; Pathfinder type:      600 kHz Pathfinder
; Setup name:         Pathfinder.txt
; Setup type:         Bottom Track only
;
; NOTE: Any line beginning with a semicolon in the first column is
;       treated as a comment and is ignored by the software.
; Modified Last: 18 March 2015
;-----
; *****
; Pathfinder Basic Setup Commands
; *****
; Restore factory default settings in the Pathfinder
CR1
; set the data collection baud rate to 15200 bps,
; no parity, one stop bit, 8 data bits
CB811
; Flow Control - set to default
CF11110
; *****
; Pathfinder Bottom Track Setup Commands
; *****
; Enable single-ping bottom track,
BP001
Set maximum bottom search depth to 200 meters
BX01100
; *****
; Pathfinder Environment Setup Commands
; *****
; Set Heading Alignment to 0 degrees
; NOTE. If the Pathfinder is rotated +45 degrees starboard
; (recommended alignment), set EA to EA+45000
EA00000
; Set manual transducer depth in case depth sensor fails
ED0000
; Set Salinity to saltwater
ES35
; Output earth coordinates, use tilts, allow 3 beam
; solutions and bin mapping
EX10111
; Set to use internal sensors
EZ10000010
; *****
```

```

; Pathfinder Timing Setup Commands
; *****
; Set Time between Ensembles to zero (Pathfinder will ping as fast as possible)
TE00000000
; Set Time between Pings to zero (Pathfinder will ping as fast as possible)
TP00:00.00
; *****
; Pathfinder Water Profiling Setup Commands
; *****
; Note: By default, water profiling is turned off.
;       To use water profiling, set the WP command >0
WP0
; Bin size set to 400 cm
WS0400
; Number of bins set to 50
WN050
;
; *****
; Pathfinder Expert Command Section
; *****
;
; CAUTION - Editing or adding expert commands to the command file will
;           allow items that if set incorrectly can cause the data to
;           be the wrong format, bad, and/or uncorrectable even in post
;           processing.
;
; Disable Water-Mass Layer Mode (default)
BK0
; *****
; Turnkey mode on - Pathfinder will ping 30 seconds after power turned on.
; CT n T
; n = 0 to 2 (0 = Off, 1 = Turnkey On-Output Serial, 2 = Turnkey On-Output Ethernet)
; T = 5 to 100 (integer seconds)
; *****
#CT 1 30
; Environmental Data Output - sets specialized attitude data types
; Phased Array transducer default
#EE0000010
; Set Heading Bias to 0 degrees
;
; NOTE. Set #EV = [(local magnetic declaration)*100]
#EV00000
; Select type of external sensor to use
#EY 0 0 0 0 0 0 0 0
; Set output data format to #PD0
#PD0
;-----
; Save this setup to non-volatile memory in the Pathfinder
CK
; Start pinging
CS

```

The commands shown in Table 14 explain each command set by the example command file. These commands directly affect the range of the Pathfinder, standard deviation (accuracy) of the data, ping time, and power usage.

Teledyne RD Instruments **strongly recommends** that the commands shown in Table 14 be the **minimum** commands that should be sent to the Pathfinder.



Although these are TRDI's recommended minimum commands, they may not be the only commands needed for the deployment to be successful!

Editing or adding expert commands (#xx) to the command file will allow items that if set incorrectly can cause the data to be the wrong format, bad, and/or uncorrectable even in post processing.



The 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.

Table 14: Recommended Commands

Command	Choices	Description
CR1	Sets factory defaults	This is the first command sent to the DVL to place it in a "known" state.
CBxxx	CB111 to CB811	Sets the baud rate from 1200 to 115200 baud. Recommended to leave at default setting of 9600 baud (CB411) (see CB - Serial Port Control).
CF11110	See manual for description	Flow control - Recommended to leave at default setting of CF11110 (see CF - Flow Control).
BP1	BP0 (off) to BP999	Sets the Bottom Track Pings Ping to once per ensemble. Recommended to leave at default setting of BP1 (see BP - Bottom-Track Pings per Ensemble).
BX01100	600 kHz = BX1100	Sets the Maximum Tracking Depth to 110m for Pathfinder 600 (1100 decimeters) (see BX - Maximum Tracking Depth).
EA00000	EA-17999 to EA18000	Heading alignment uses beam-3 as the heading alignment. If the Pathfinder is rotated +45 degrees starboard (recommended alignment), set EA to EA+45000 (see EA - Heading Alignment).
ED0000	ED0 to ED65535	Manually set depth of the transducer in decimeters. If a pressure sensor is available, the ED-command will be used only if the depth sensor fails (see ED - Depth of Transducer).
ES35	ES0 to ES40	Salinity of water is set to 35 (saltwater) (see ES - Salinity).
EX10111	Coordinates, Use Tilts, 3-beam solution, bin mapping	Sets coordinate system, use tilts, allow 3-beam solutions, and allow depth cell (bin) mapping (see EX - Coordinate Transformation).
EZ22000010	Sensor source	Calculate speed of sound from internal sensor readings (Temperature) (see EZ - Sensor Source).
TE00:00:00.00	Time per ensemble	Ping as fast as possible (see TE - Time Per Ensemble).
TP00:00.00	Time per ping	Ping as fast as possible (see TP - Time Between Pings).
WP0	WP0 to WP16384	Water Profiling – The default setting WP0 will turn off water profiling (see WP - Pings Per Ensemble).
WS0200	WS10 to WS400	Sets the depth cell size in cm. Recommended to leave at default setting (see WS - Depth Cell Size).

Table 14: Recommended Commands

Command	Choices	Description
WN030	WN1 to WN255	Sets the number of depth cells. Recommended to leave at default setting of WN030 (see WN – Number of Depth Cells).
BKx	BK0, BK1, BK2, BK3	This command selects the when the Water-Mass Layer ping will be used. Recommended to send the BK0 (default) command to disable the Water-Mass Layer (this also disables the #BL command) (see BK - Water-Mass Layer Mode). If the Water-Mass Layer pings need to be enabled, see the BK and #BL commands.
#BLmmmm,nnnn,ffff	Min, Near, Far layer boundary	This command sets the Water-Mass Layer boundaries. Recommended to leave at the default settings: #BL80,160,240 (see BL - Water-Mass Layer Parameters).
#BJtc*hrn***	Bottom Data Types	This command sets the Bottom Data Types that will be output. Recommended to leave at the default setting #BJ100 000 000 (see BJ – Data Type Output Control).
CT n T	n = 0 to 2 (0 = Off, 1 = Turnkey On-Output Serial, 2 = Turnkey On-Output Ethernet) T = 5 to 100 (integer seconds)	Setting the CT command to CT 1 30 (serial) or CT 2 30 (ethernet) turns the Turnkey mode on. The Pathfinder will ping 30 seconds after power is turned on (see CT - Turnkey Operation).
#EE0000010	Environmental data output	Selects specialized Environmental data. Recommended to leave at the default settings: default#EE0000010 (see EE - Environmental Data Output).
EV00000	EV-17999 to EV18000	Sets the Heading Variation in degrees. Set EV = [(local magnetic declination)*100] (see EV - Heading Bias).
#PDx	PD0 (default), PD4, PD5, PD6	Sets the output data format (see PD0 Output Data Format).
CK	Keep parameters as user defaults	If power is lost and then restored, all commands will be restored as last sent (see CK - Keep Parameters). Sent right before the CS-command.
CS	Start ping	Last command sent to begin collecting data (see CS – Start Ping (Go)).



The CR1 command must be the first command sent to the Pathfinder. The CK command must be sent just before the CS command. Other commands may be sent in any order.

Sending Commands to the Pathfinder

To send the commands to the Pathfinder:

1. Place the Pathfinder system in water.
2. Start *TRDI Toolz*.
3. Send a BREAK to the Pathfinder by pressing the  icon. When the Pathfinder receives a BREAK signal, it responds with a wake-up message similar to the one shown below. The Pathfinder is now ready to accept commands at the “>” prompt.

```
Pathfinder
Teledyne RD Instruments (c) 2017
All rights reserved.
Firmware Version: 67.xx
```

>

4. Use *TRDI Toolz* to set the clock; click **Tools, PC Time to ADCP**.
5. To test the system, use the [PA command](#).
6. To send the command file, on the **Tools** menu, select **Script Editor**.
7. 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.
8. Click the **Send** icon.



Teledyne RD Instruments does not recommend the use of entering commands one at a time as the primary way of deploying a Pathfinder system as **any incorrect command setting can have severe consequences to data collection**. Always use a script file to send the commands. See the [Command Descriptions](#) and [Introduction to Output Data Format](#) sections for information on each command setting.



Script files can have any extension as long as they are ASCII text files.

NOTES

Chapter 4

MAINTENANCE



In this chapter, you will learn:

- How to spot problems
- How to do periodic maintenance items on the PathFinder

Replaceable Parts

Use the following table to order replacement parts:

Table 15: Pathfinder ROV Spare Parts – Part of 75BK6084-00

Description	Part number	Where used
Anode, housing, top	81B-4146-00	Anodes for Housing Exterior
Anode, housing, bottom	810-4106-00	
Anode Screw	M5X0.8X10FH	
Anode Screw	M2.5X0.45X8FH	
M4 Washer	M4WASHSMOD	Closing hardware for housing
M4 Split Washer	M4WASHSPL	
M4 Nylon Washer	M4WASHNYLON	
M4 Nut	M4X0.7NUT	
Isolator	91145A148	
M4 Bolt	M4X0.7X25SH	

Table 16. 75BK6087-00 – Kit, Field Service, ROV Pathfinder

P/N	Description	QTY
M4WASHSMOD	WASHER, SMALL OD, 8MM SST	14
M4WASHSPL	WASHER, SPLIT LOCK, SST	8
M4WASHNYLON	WASHER, FLAT, 9MM OD, NYLON	8
M4X0.7NUT	NUT, HEX, SST	8
91145A148	ISOLATOR, 1/4 LONG, SCREW #8, NYLON	8
M4X0.7X25SH	SCREW, BUTTON/SOCKET HEAD 316 SST	8
81B-4146-00	ANODE, PIONEER 300	2
810-4106-00	ANODE, SMALL OD	4
M5X0.8X10FH	SCREW, FLAT HEAD, SST	2
M2.5X0.45X8FH	SCREW, FLAT HD SKT HD, 316SST	4
2-152	O-RING, -152, EPDM 70 DURO	2
97Z-6084-00	O-RING, 2-015 .070DIA X.551 ID, EPDM, DURO 90A, VENT PLUG	2
7295K1	TIE WRAP, FASTENER MOUNT, 4.5	2
97Z-6007-00	O-RING, 2-011, DURO 70, EPDM	4
97Z-6009-00	O-RING, 2-014 DURO 70, EPDM	2
97Z-6036-00	O-RING, 2-166, 70 DURO, EPDM	2
97Z-6084-01	O-RING, 3-094, .072DIA X.351 ID, EPDM, DURO90A, VENT PLUG	2
DES6	DESICCANT, SEALED BAG, 1/6 UNI	1
5020	SILICONE LUBRICANT, 4-PACK	2
425	THREADLOCKER, PLAS SCREW	1
81B-6042-00	O-RING TOOL, TELEDYNE	1

Table 16. 75BK6087-00 – Kit, Field Service, ROV Pathfinder

P/N	Description	QTY
M7COMBINATION	WRENCH, #7MM COMBINATION	1
7289A13	KEY, HEX, 2.5MM	1
84Z-6000-00	TOOL BAG, CANVA	1
90Z-8002-00	CD, COMBINED, NAVIGATION	1
95B-6117-00	Pathfinder DVL Quick Start Card	1

Table 17. 75BK6089-00 – Kit, Field Service, OEM Pathfinder

P/N	Description	QTY
5020	SILICONE LUBRICANT, 4-PACK	2
2-037	O-RING, FACE SEAL, DURO 70	2
84Z-6000-00	TOOL BAG, CANVAS	1
7289A13	KEY, HEX, 2.5MM	1
5503A37	L-KEY, HEX, 2MM	1
81B-6042-00	O-RING TOOL, TELEDYNE	1
90Z-8002-00	CD, COMBINED, NAVIGATION	1
95B-6117-00	Pathfinder DVL Quick Start Card	1

Table 18. Kit, Accessories, OEM Pathfinder

P/N	Description	QTY
2-152 (300 and 1000 meter) 2-153 (6000 meter)	O-RING, EPDM 70 DURO	2
4491K84	CAP, PROTETIVE SHIPPING, EXP600 PA	1
5020	SILICONE LUBRICANT, 4-PACK	2
5503A37	L-KEY, HEX, 2MM MCMaster-CARR	1
84Z-6000-00	TOOL BAG, CANVAS	1
73B-6060-001	CABLE, PIGTAIL, OEM, PATHFINDER, 1 METER	1
95B-6120-00	QUICK START, PATHFINDER, OEM	1
95B-6121-00	GUIDE, INTEGRATION, OEM	1
90Z-8002-00	CD, COMBINED, NAVIGATION	1
97B-7012-00	SHIPPING CASE, CARDBOARD, OEM PATHFINDER	1

Inspection Schedule

TRDI recommends the following regular inspection to be performed before every deployment:

Table 19: Visual Inspection Criteria

Item	Inspection Criteria
Transducer	The urethane coating on the transducer face is important to Pathfinder watertight integrity. Mishandling, chemicals, abrasive cleaners, and excessive depth pressures can damage the transducer ceramics or urethane coating. Inspect the transducer face for dents, chipping, peeling, urethane shrinkage, hairline cracks, and damage that may affect watertight integrity or transducer operation. Repair of the transducer face should only be done by TRDI. 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 two to three years maximum. Check the Power/Comm connector for cracks or bent pins before each deployment (see Figure 25).
Cables and Connectors	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. Repair of the connectors should only be done by TRDI. The connector is made of rubber and as a general maintenance item TRDI recommends that the connector be replaced every five years or whenever visible signs of wear or corrosion appear.
Housing paint / anodize coating	Inspect the housing, and transducer assembly for corrosion, scratches, cracks, abrasions, or exposed metal (silver-colored aluminum). Be critical in judgment; the useful life of the Pathfinder depends on it. Thoroughly clean the exterior of the Pathfinder after retrieval. See Removing Biofouling for details. After each deployment, systems need to be cleaned thoroughly.
Anodes	Inspect the anodes on the transducer assembly and housing for corrosion and pitting. If the RTV has decayed enough to let water enter between the screws and the anode, replace the RTV. Replace anodes whenever the mounting screw is in less than 75% in contact with the anode. Replace all anodes every year.
Hardware (bolts, etc.)	Check all bolts, washers, and split washers for signs of corrosion before each deployment. TRDI recommends replacement every 5 years. Damaged hardware should never be used.



To ensure continued optimal results from the Pathfinder DVL, TRDI recommends that every system be returned to our factory for an inspection every two to three years. We'll provide the unit with a thorough multi-point inspection, and notify if any refurbishment services are required to properly maintain the unit. To learn more about this service, please [contact field service](#).

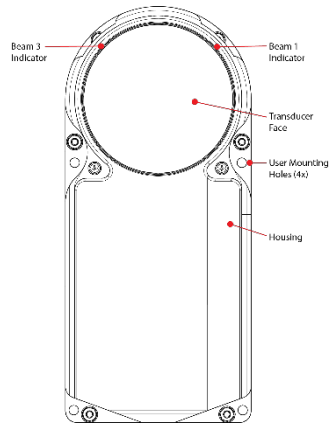


Figure 24. Transducer View

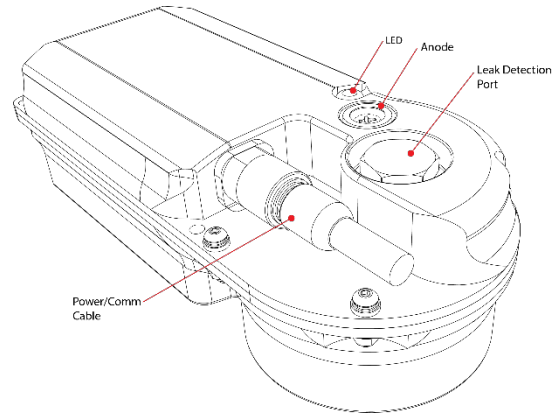


Figure 25. Top View

Periodic Maintenance Items

These maintenance items should be done prior to using the DVL.

Cleaning the Cable Connectors

After a deployment, clean and remove any accumulated sand or mud from the both the connector on the Pathfinder DVL and the socket on the cable.

To clean the connectors:

1. Flush the connector pins and sockets with soap and fresh water (deionized water if available) to remove all dirt, grit, and lubricant.
2. Rinse out with alcohol, allowing the connector to air dry.



Do **NOT** use spray-based contact cleaner. The use of some oil-based propellants in spray cans can cause conductivity problems in neoprene.

Transducer Inspection



Never set the transducer face on a rough surface; always use foam padding to protect the transducer.

Based on experience, TRDI knows that **most** DVLs need to have the urethane inspected after 2 to 3 years of field use. 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 cup. By returning the system every 2 to 3 years, TRDI can inspect it for early signs of urethane failure and repair it through our Refurbishment Service. At the same time, TRDI will make any necessary upgrades to boards, assemblies, and firmware. If the Refurbishment Service is not needed, TRDI can upgrade the system as part of one of our Inspection Services. Proper care, general maintenance, and this routine service period ensures that the Pathfinder system lasts for a minimum of 10 years with no loss in performance.



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

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 face 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 Pathfinder 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, send the Pathfinder to TRDI for repair. If the barnacles can not be removed 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 Pathfinder before placing it in the storage case to avoid fungus or mold growth. Do not store the Pathfinder in wet or damp locations.

Zinc Anode Inspection and Replacement

The Pathfinder has three zinc anodes on the instrument housing, one anode on the top of the transducer housing, and two on the bottom of the housing. If the Pathfinder does not have exposed bare metal, a properly installed anode helps protect the Pathfinder 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. Replace all anodes every year.

To inspect the anodes:

1. Inspect the anodes on the transducer assembly and housing for corrosion and pitting. If most of an anode still exists, it may not need to be replaced.
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 there are doubts about the condition of the anodes, remove and replace the anode.

Zinc Anode Electrical Continuity Check

Check the electrical continuity using a digital multi-meter (DMM). Measure the resistance between the two anodes attached to the same part of the instrument (transducer or housing). The resistance should be less than two ohms. If not, reinstall the affected anode.

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 Pathfinder 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.



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. Although TRDI has rarely seen corrosion around the anode mounting holes, **we would like to remind our customers that it is good practice to always inspect for corrosion in this (and all) areas between deployments.**

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 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.



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



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.

Do not use magnesium anodes. Magnesium rapidly corrodes aluminum housings.

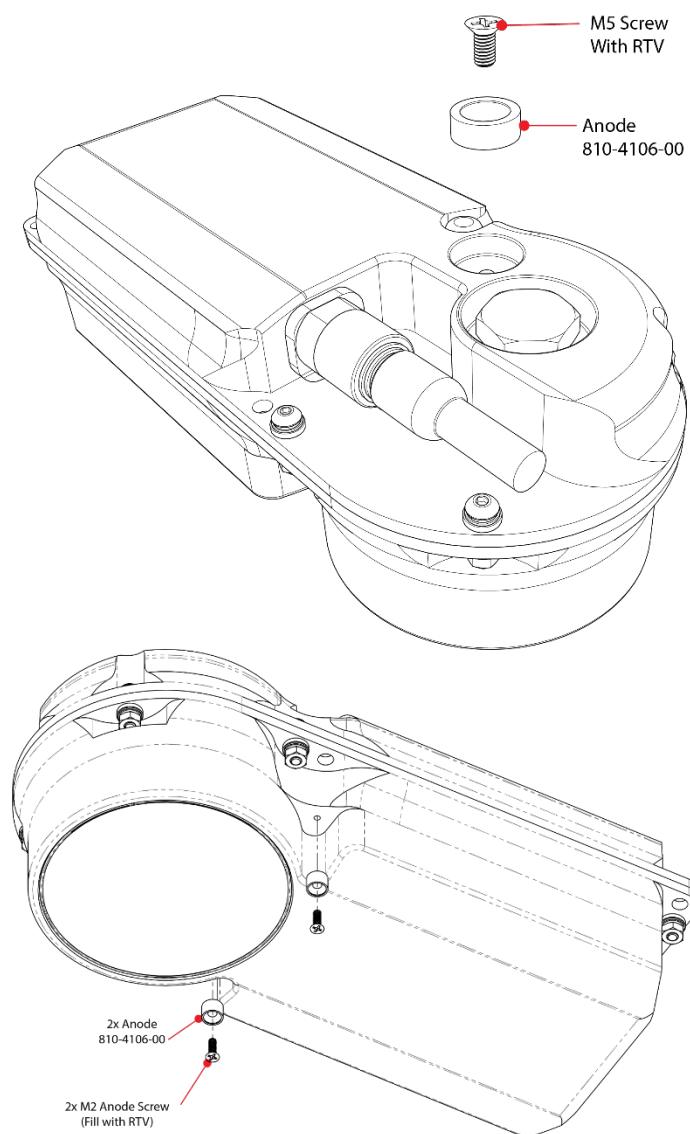


Figure 26. Replacing an Anode

Protective Coating Inspection

For more protection, the case and the transducer assembly are first anodized per MIL-A-8625, Type III, Class 2, Nickel Acetate Seal. Do not damage the surface coatings when handling the Pathfinder.

Inspect the housing, and transducer assemblies for corrosion, scratches, cracks, abrasions, exposed metal (silver-colored aluminum). **Be critical in your judgment; the useful life of the Pathfinder depends on it.**



If there is any damage to the anodizing near the edges of the urethane transducer face or the connectors, **DO NOT DEPLOY THE PATHFINDER**. Please contact TRDI Support Team for advice.

Long Term Maintenance Items

The O-Rings and desiccant should be replaced every two years. Firmware updates may be done when needed.



Before opening the system, order the 757BK6087-00 Kit, Field Service, ROV Pathfinder or 757BK6089-00 Kit, Field Service, OEM Pathfinder. These maintenance kits include all the hardware, O-rings, and desiccant required to seal the system.

Instructions on how to open and close the housing are included with the ROV field service kit.

Installing Firmware and Feature Upgrades

Pathfinder firmware and feature upgrades can be requested from TRDI field service. Contact Field Service at rdifs@teledyne.com or by phone 858-842 2700.

Firmware Upgrades

To install a firmware upgrade using the serial port:

1. Connect the Pathfinder to the computer as shown in [Setting up the Pathfinder System](#).
2. Run the *Pathfinder_XX-xxx.exe* file (where XX-xxx is the firmware version). This is a self-extracting zip file that contains all the files needed for the upload. You can specify a location to where the files will be extracted. If no location is specified, the files will be extracted to the current folder.
3. The default serial port in the firmware download batch file is COM1. If the Pathfinder is connected to another serial port edit the *Pathfinder.bat* file. Open the *Pathfinder.bat* file with Notepad® and change the setting to the serial port number. For example, if the Pathfinder is connected to COM6, change the line **set port=1** to **set port=6**. Save the file, and then close.
4. Double-click on the *Pathfinder.bat* file. This will start the firmware upload process.
5. If you are not able to install the new firmware, contact Customer Service.
6. After successfully upgrading the firmware, use *TRDI Toolz* to test the ADCP (see [Testing the Pathfinder System](#)).

To install a firmware upgrade using the Ethernet port:

Firmware version 67.20 and above adds support for firmware updates over Ethernet using *NavUI* or *TRDI Toolz* version 1.02.00.03 or higher software. This also requires Ethernet Module Firmware version 1.04 or higher. See [Ethernet Module Firmware Update](#).



For information on *NavUI*, see the *NavUI* documentation.

1. Connect to the Pathfinder using Ethernet and *TRDI Toolz* as shown in [Connecting to the Pathfinder](#).
2. On *TRDI Toolz*, click **Tools, Firmware Update**.
3. Navigate to where the firmware file is located. The file name will be *PF_xx.xx.m0*, where *xx.xx* is the firmware version.
4. Click **OK**. The firmware will install. It takes several minutes to load the new firmware and the screen may be blank during the update process. Do not close *TRDI Toolz* while the firmware is updating.
5. Once the firmware update is complete, the Pathfinder will reboot. Close *TRDI Toolz* and reconnect to the Pathfinder.
6. If the new firmware does not install, contact Customer Service.
7. After successfully upgrading the firmware, use *TRDI Toolz* to test the ADCP (see [Testing the Pathfinder System](#)).

Feature Upgrades

The feature upgrade installation program is used to install new capabilities in a Pathfinder system.



Contact your local sales representative if you are interested in upgrading your system.



The upgrade file is specific to the unit for which it was ordered. DO NOT attempt to install this feature for any other unit.



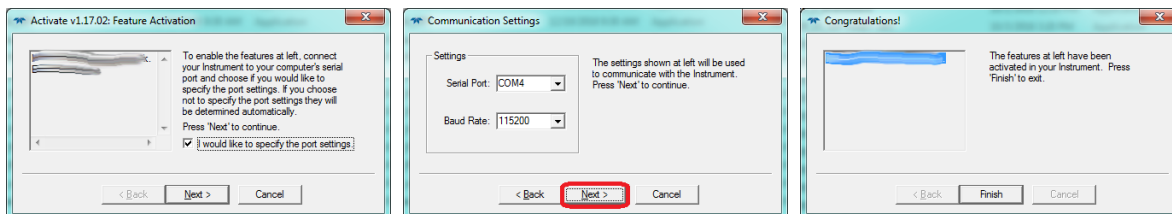
Many feature upgrades require the latest firmware version to be installed in your ADCP. If you need to update the firmware, do this before installing the feature upgrade.

To install a feature upgrade:

1. Set up the Pathfinder as shown in [Setting up the Pathfinder System](#).
2. Start the program *Activate_Pathfinder_xxxx.exe* (where xxxx is the Pathfinder's serial number) to install the feature file using Serial communications.

If you are using *NavUI* or *TRDI Toolz* to install the feature file using Ethernet communications, use the *Pathfinder_xxxx.feature* file. For *TRDI Toolz*, click **Tools, Activate Features**.

3. The installation program will start. The program is encoded with the Pathfinder's serial number and the requested feature upgrade.
4. To select the port settings, check the **I would like to specify the port setting** box and click **Next**.



5. Select the **Serial Port** and **Baud Rate**.
6. Click **Next** to install the feature upgrade.
7. Click the **Finish** button to exit the program.
8. Start *TRDI Toolz* and use the [OL command](#) to verify the feature upgrade has been installed.

NOTES

Chapter 5

RETURNING SYSTEMS TO TRDI FOR SERVICE



In this chapter, you will learn:

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

Shipping the Pathfinder

This section explains how to ship the Pathfinder.



Remove all customer-applied coatings or provide certification that the coating is nontoxic if shipping a Pathfinder 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 the equipment is returned 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 certification is not provided, TRDI will return the equipment or send it to a customer-specified cleaning facility. All costs associated with customer-applied coatings will be at the customer's expense.

When shipping the Pathfinder 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 Pathfinder.

Use the original shipping crate whenever possible. If the original packaging material is unavailable or un-serviceable, 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 handling.
5. In any correspondence, refer to the Pathfinder 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 Pathfinder 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 the instrument, do one of the following:

- Contact Customer Service Administration at rdicsadmin@teledyne.com
- Call +1 (858) 842-2600

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. Consolidated shipping 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 Pathfinder 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 the 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. Consolidated shipping 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 6

SPECIFICATIONS



In this chapter, you will learn:

- Operational Specifications
- Outline Installation Drawings

A brief review of Pathfinder operation may help explain the specifications listed in this section. The discussion below regarding water profiling is generally applicable to bottom track as well.



The specifications and dimensions listed in this section are subject to change without notice.

The Pathfinder emits an acoustic pulse called a PING. The seabed and scatterers that float ambiently with the water currents reflect some of the energy from the ping back to the Pathfinder transducer. The Pathfinder uses the return signal to calculate a velocity.

The energy in this signal is the *echo intensity*. The echo intensity returned from the seabed is used to detect the bottom. The echo intensity returned by floating scatterers 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 Pathfinder reduces this statistical uncertainty by averaging a collection of pings. A collection of pings averaged together is an *ensemble*. The Pathfinder's maximum *ping rate* limits the time required to reduce the statistical uncertainty to acceptable levels.

The Pathfinder does not measure velocity at a single point; it measures its speed over the seabed, i.e. Bottom Track, its speed through the water current, i.e. Water Track and current velocities throughout the water column, i.e. Water Profile.

When bottom tracking, the Pathfinder calculates velocity data relative to itself. The velocity data has both speed and direction information. If the Pathfinder is moving, and is within range of the bottom, it can obtain a velocity from returns off the bottom. The bottom track information can be used to calculate the absolute velocity of the water. The Pathfinder can get absolute direction information from a heading sensor.

When water profiling the Pathfinder 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 Pathfinder produces two profiles, one for velocity, and one for echo intensity.

The following tables list the specifications for the Pathfinder. About the specifications:

1. Except where noted, these specification tables 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 Pathfinder motion, and typical echo intensity levels.
2. The total measurement error of the Pathfinder is the sum of:
 - Long-term instrument error (as limited by instrument accuracy),
 - The remaining statistical uncertainty after averaging,
 - Errors introduced by measurement of Pathfinder heading and motion.
3. Because individual pings are independent, the statistical uncertainty of the measurement can be reduced according to the equation:

$$\frac{\text{Statistical Uncertainty for One Ping}}{\sqrt{\text{Number of Pings}}}$$



Specifications subject to change without notice.

Operational Specifications

600 kHz	
Bottom Tracking	
Maximum Altitude ^{(1) (2)}	89 m (150 m optional)
Minimum Altitude	0.2 m (<20 cm with low altitude option)
Velocity Range ⁽³⁾	±9 m/s (or +16 m/s upon request)
High Accuracy Bottom Track Long Term Accuracy ⁽⁴⁾	±0.2% ± 0.2cm/s
Base Bottom Track Long Term Accuracy ^(5, 7)	±1.15% ± 0.2cm/s
Precision @ 1 m/s	±0.5 cm/s @ ½ alt.
Precision @ 3 m/s	±1.5 cm/s @ ½ alt.
Precision @ 5 m/s	±2.3 cm/s @ ½ alt.
Resolution	0.1cm/s
Ping Rate ⁽⁶⁾	12 Hz max
Water Profiling	
Maximum Range ^{(1) (2)}	47 m
Minimum Range	1.9 m
Velocity Range ⁽³⁾	±12 m/s
Long Term Accuracy	0.3% ± 0.2 cm/s
Standard Deviation of WP measurement at 1 m/s	±7.5 cm/s @ 2m bin size
Standard Deviation of WP measurement at 3 m/s	±7.5 cm/s @ 2m bin size
Standard Deviation of WP measurement at 5 m/s	±7.7 cm/s @ 2m bin size
Resolution	1 mm/s
Cell Sizes	0.1 to 4 m
Number of Depth Cells	1 to 255
Acoustic	
Center Frequency	614.4 kHz
Source Level (re 1μPa)	215 dB @ 1m
1-Way Beam Width	2.2°
Number of Beams	4-phased array
Beam Angle	30°
Bandwidth (nominal)	6.25% of center frequency
Depth Rating	
Maximum Depth	300m, 1000m

1. @5°C and 35 ppt, salinity, @ max V.

2. Maximum range may be reduced due to flow noise.

3. When mounted with beam @ 45°. Also, for platforms with forward velocity higher than reverse (or vice versa), the maximum velocity can be increased to [-2 m/s -> +16 m/s] for bottom track via firmware modification.

4. ECCN 6A001.

5. ECCN 6A991.

6. @ 5% of maximum altitude

7. Max speed = ±1.6 m/s (<0.35 m altitude) & ±9 m/s (≥0.35 m altitude) No Tilt.

Environmental Specifications

Parameter	Value
Operating Temperature	-5 to 45 Degrees C
Storage Temperature	-30 to 60 Degrees C
Vibration (Operation)	IEC 60945, 4th ED, 2002-08
Vibration (Transport)	IEC 60721-3-2, 2Nd Ed, 1997-3
Shock (Transport)	IEC 60721-3-2, 2Nd Ed, 1997-3
Shock (Operation)	IEC 1010-1

Electrical Specifications

Parameter	Value
DC Input	10.7 to 36 VDC (24 VDC typical)
Surge Current	< 4 A
Average Power while transmitting @24VDC/32 VDC	2.6W (3.4 W with Ethernet enabled)
Average Quiescent Power	1.1W (2 W with Ethernet enabled)

Communications Specifications

Parameter	Value
Communications	Ethernet & RS-232
Master Channel Baud Rate	1200 to 115,200 bps
Ensemble Types	PD0, PD4, PD5, PD6, PD13

Outline Installation Drawings

96B-9040-00	OUTLINE/INSTALLATION, OEM PATHFINDER
96B-9041-00	OUTLINE/INSTALLATION, ROV PATHFINDER

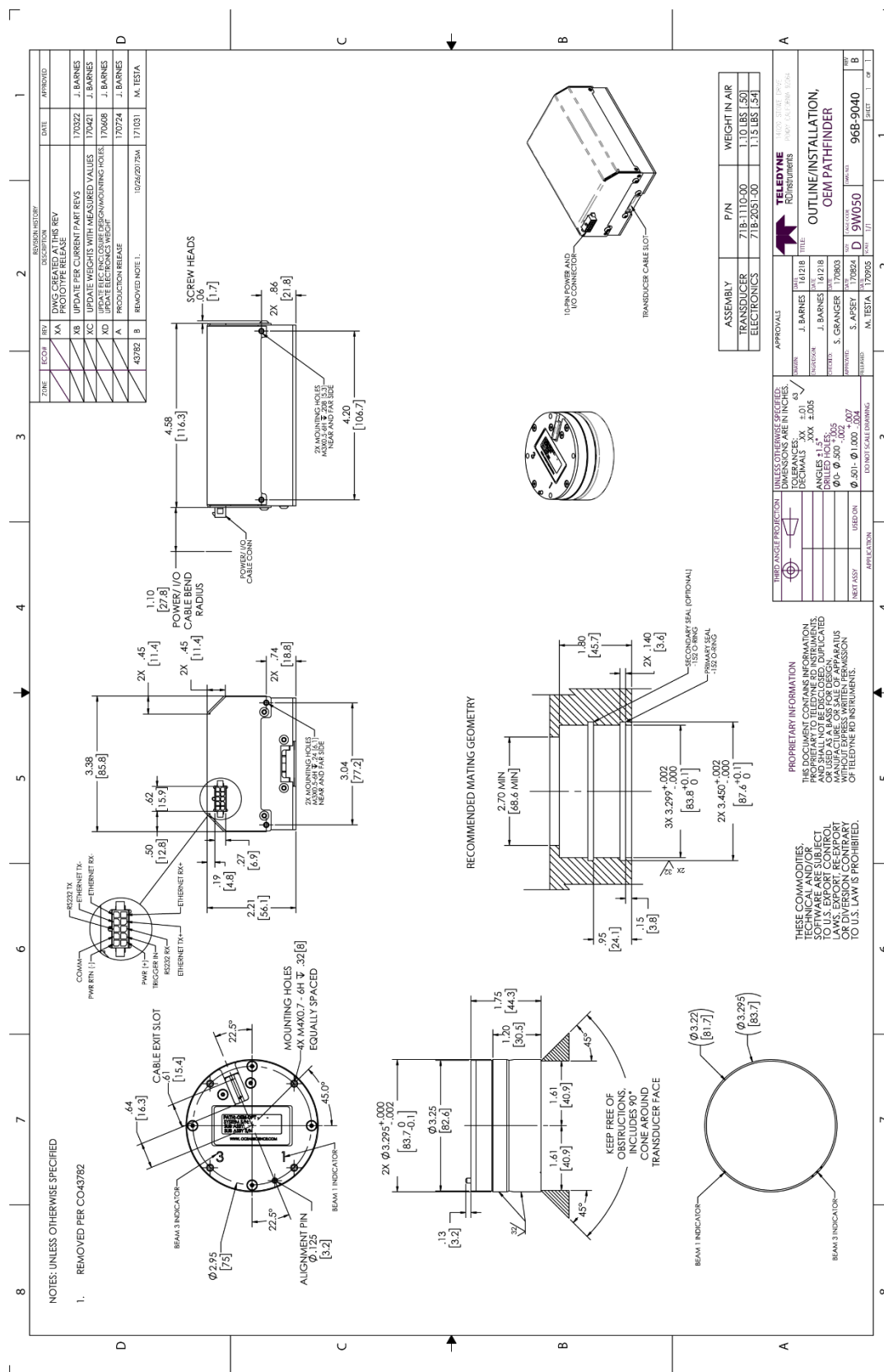


Figure 27. Outline Installation Drawing – OEM

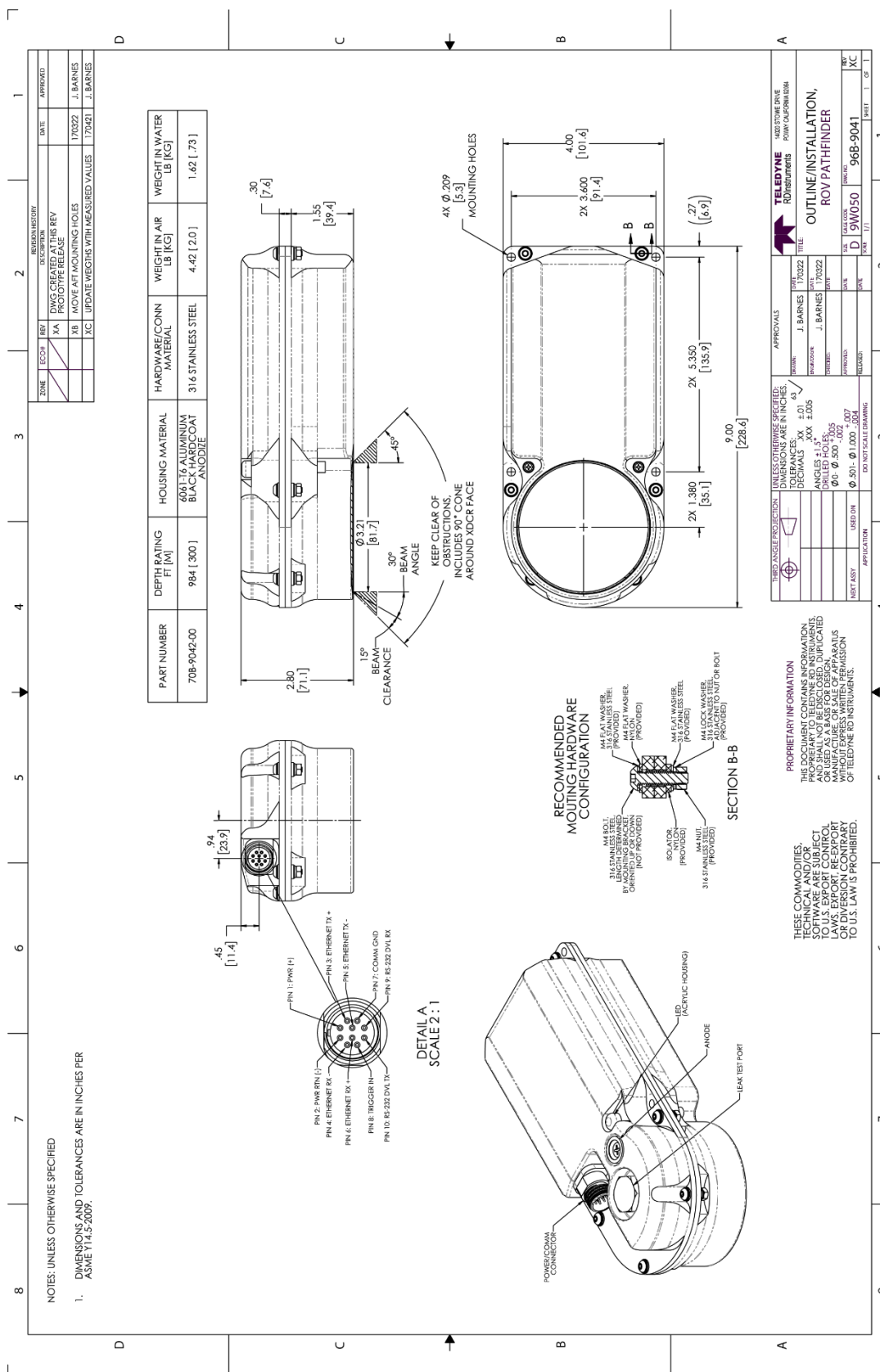


Figure 28. Outline Installation Drawing – ROV Pathfinder

Chapter 7

COMMANDS



In this chapter, you will learn:

- Command formats
- Command descriptions

This section defines the commands to set up and control the Pathfinder. Teledyne RD Instruments recommend using a *TRDI Toolz* script file to control the Pathfinder because entering commands directly from a terminal can be difficult. *Make sure to read and understand [Creating or Modifying Command Files](#) before deploying the Pathfinder.* Most Pathfinder command settings use factory-set values (Table 20). If these values are changed without thought, the deployment may be ruined. *Be sure to know what effect each command has before using it.* Call Teledyne RD Instruments for help in understanding the function of any command.



This section applies to Pathfinder firmware 67.01.

When new firmware versions are released, some commands may be modified, added, or removed. Read the README file on the upgrade disk or online. When an addition or correction to this manual is needed, an Interim Change Notice (ICN) will be posted to our web site. Please check our Teledyne RD Instrument's web site often at www.rdinstruments.com.

Data Communication and Command Format

Enter commands with a Windows®-compatible computer running *TRDI Toolz*. The Pathfinder communicates with the computer through an RS-232 serial interface or Ethernet. TRDI initially sets the Pathfinder at the factory to communicate at 115200 baud, no parity, and one stop bit.

Immediately after power is applied to the Pathfinder, it enters the STANDBY mode. Send a software break may be sent by sending either “+++” or “==”. When the Pathfinder first powers up or receives a BREAK signal, it responds with a wake-up message similar to the one shown below. The Pathfinder is now ready to accept commands at the “>” prompt from either a terminal or computer program.

```
Pathfinder
Teledyne RD Instruments (c) 2017
All rights reserved.
Firmware Version: 67.xx
```

```
>
```



If using a terminal/program other than *TRDI Toolz*, the BREAK length (up to down transition) must last at least 300 ms. The Pathfinder may respond to breaks shorter than this, so care must be taken to avoid transients on the communication lines.



By default, the Turnkey mode is OFF (CT0). If Turnkey mode is ON (CT1) then the Pathfinder DVL will ping within 10 seconds if a command is not received (see [CT - Turnkey Operation](#)).

Command Input Processing

Input commands set Pathfinder 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> [input]
```

If the entered command is valid, the Pathfinder executes the command. If the command is one that does not provide output data, the Pathfinder sends a carriage return line feed <CR> <LF> and displays a new “>” prompt. Continuing the example,

```
>BP00001<CR>    [the original input]
>                [Pathfinder response to a valid, no-output command]
```

If a valid command is entered that produces output data, the Pathfinder executes the command, displays the output data, and then redisplay 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 Pathfinder responds with an error message similar to the following.

```
>BPA<CR>                                     [input]
>BPA  ERR:  Bad command parameters!<CR><LF>    [Pathfinder response]
>
```

After correctly entering all the commands for the application, send the CK to save the setup and then a CS command to begin the data collection cycle.

Data Output Processing

After the Pathfinder completes a data collection cycle, it sends a block of data called a *data ensemble* through the serial communication lines. A data ensemble consists of the data collected, processed, and averaged during the ensemble interval (see [TE – Time Per Ensemble](#)). A data ensemble can contain header, leader, velocity, correlation magnitude, echo intensity, percent good, and status data.

Pathfinder output data can be in either hexadecimal-ASCII (Hex-ASCII) or binary format (set by [CF - Flow Control](#)). The Hex-ASCII mode is useful when using a terminal to communicate with, and view data from the Pathfinder. The binary mode is useful for high-speed communication with a computer program. Do not use the binary mode to view data on a terminal because the terminal could interpret some binary data as control codes.



Most of Teledyne RD Instruments' software supports binary PDO Output Data Format.

When data collection begins, the Pathfinder uses the settings last entered (user settings) or the factory-default settings. The same settings are used for the entire deployment. If the user settings are saved (see [CK - Keep Parameters](#)) then the Pathfinder will always use the user settings until a factory default is recalled, or use the last entered settings, if any, or until power is turned off. The following three rules apply for setting-up the Pathfinder:

1. The last entered command of a particular command takes precedence,
2. The last entered commands will be kept in volatile memory until power is shutdown (only CK will keep these in non-volatile memory, see [CK - Keep Parameters](#)).
3. The user can recall the factory default-settings at any time (see [CR – Retrieve Parameters](#)).

The Pathfinder will continue to be configured from volatile memory until it receives a CR-command or until the volatile memory loses its backup power. If the Pathfinder receives a CRO it will load into volatile memory the command set last stored in non-volatile memory (semi-permanent user settings) through the CK-command. If the Pathfinder receives a CR1, it will load into volatile memory the factory default command set stored in ROM (permanent or factory settings).

Command Summary

Table **20** gives a summary of the Pathfinder input commands, their format, default setting, whether the Pathfinder will follow the command change if sent while pinging, and a brief description of the parameters they control. Commands that start with the # sign are considered “expert” commands. Commands sent while pinging will be used on the next ensemble after the one during which they are received.



When newer firmware versions are released, some commands may be modified or added. Read the README file on the upgrade disk or check TRDI's web site for the latest changes.



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.rdinstruments.com). Please check our web site often.



The Pathfinder DVL accepts command changes during operation without the need to stop the ping cycle (by sending a <BREAK>). This allows for dynamic setup configuration without stopping the operation of the Pathfinder DVL. These dynamic setup commands are defined in the column **Dynamic Commands** in the table below.

Table 20. Pathfinder Commands and Defaults

Command	Default	Dynamic Command	Description
?	N/A	N/A	Shows command menu
<BREAK> End	N/A	N/A	Interrupts or wakes up Pathfinder DVL and loads last settings used
OL	N/A	N/A	Features
Y	N/A	N/A	Display banner
#B1n	0	Yes	Blank Range with Bad Velocity [0..1]
#B2n	0	Yes	Depth Memory Timeout [0=off, 1-30s]
#BA $\overline{nnn}$	024	Yes	Evaluation amplitude minimum (1 to 255 counts)
#BB $\overline{nnnn}$	0005	Yes	Bottom Blanking Interval (cm)
#BC $\overline{nnn}$	220	Yes	Bottom Correlation Magnitude minimum (0 to 255 counts)
#BE $\overline{nnnn}$	1000	Yes	Bottom Error velocity maximum (0 to 9999 mm/s)
#BF $\overline{nnnnn}$	00000	Yes	Bottom Depth guess (1 to 65535 dm, 0 = automatic)
#BH $\overline{nnn nnn}$	105,180	Yes	Gain Switch Threshold (0-255cnts:lo;hi)
#Bl $\overline{nnn}$	005	Yes	Gain Switch Altitude (meters)
#BJ $\overline{nnnnnnnnn}$	100000000	No	Bottom Data Out {t;c;*;h;r;*;*;*;}
BKn,#BK $\overline{n}$	0	Yes	WMass Mode [0=off 1=WB 2=LostB 3=W]
#BL $\overline{mmm,nnnn,ffff}$	80,160, 240	Yes	Water mass layer parameters: Min Size (dm), Near (dm), Far (dm)
#BM $\overline{n}$	8	Yes	Bottom Mode [8 & 9]
#BN $\overline{x,y}$	0, 999	Yes	Speed log hold/drop control (x = hold (1), clear (0), y = 0 to 999 seconds)
#BOK	025	Yes	Distance measure filter constant (0 to 100 1/100 th s)
BP $\overline{nnn}$	1	Yes	Bottom Track Pings per Ensemble
#BQ	-32768	Yes	Set outvel when over range limit (mm/s)
#BS	N/A	Yes	Clear distance traveled
BX $\overline{nnnn}$	01100	Yes	Max Depth (dm)
#BY $\overline{nn}$	20	No	Transmit Length (pct)
#BZ	1	No	Low Altitude Mode
CB $\overline{nnn}$	811	No	Serial port control (baud rate/parity/stop bits)
CE $\overline{n}$	CE1	No	Enable Ethernet
CF $\overline{nnnn}$	11110	No	Flow control
CK	N/A	No	Keep parameters as user defaults
CR $\overline{n}$	N/A	No	Retrieve parameters (0 = User, 1 = Factory, 2=Eth parms)
CS or Tab	N/A	No	Start ping
#CT $\overline{n T}$	0 10	No	Turnkey operation (0 = Off, 1 = Turnkey On-Output Serial, 2 = Turnkey On-Output Ethernet), T= 5 to 100 (integer seconds)
CX $\overline{n d t p}$	0 0 65535 0	Yes	Set Input Trigger [mode, dly, timeout, ping-once]
CZ	N/A	Yes	Put ADCP to Sleep
EA $\pm\overline{nnnn}$	+00000	Yes	Heading Alignment [.01 deg cw]
#EC $\overline{nnnn}$	1500	Yes	Speed of Sound (1400 to 1600 m/s)
ED $\overline{nnnn}$	00000	Yes	Transducer Depth (0 to 65535 dm)
#EE $\overline{abcdefg}$	0000010	No	Environmental Data Output Rsrvd[4]; Cmd[1]; Rw/Nm[1]; Snsr Out[1]
#EH $\overline{nnnn,n}$	00000,1	Yes	Heading {heading; frame}
#EI $\overline{nnnnn}$	+00000	Yes	Roll Misalignment Angle [.01 deg cw]
#EJ $\overline{nnnnn}$	+00000	Yes	Pitch Misalignment Angle [.01 deg cw]
#EP $\pm\overline{nnnnn,nnnnn,n}$	+00000, +00000,1	Yes	Tilts {pitch; roll; frame}
#ER $\pm\overline{nnnn}$	+00000	Yes	Roll [.01 deg cw]
ES $\overline{nn}$	35	Yes	Salinity (0 to 40 parts per thousand)
#ET $\pm\overline{nnnn}$	2100	Yes	Temperature (-5.00 to +40.00 degrees C) [.01 deg C]
#EU	0	Yes	Orientation [0=Switch,1=Up,2=Down]
#EV $\overline{nnnnn}$	+00000	Yes	Heading Variation [.01 deg cw]
EX $\overline{nnnn}$	10111	Yes	Coordinate Transformation (Xform:Type; Tilts; 3Bm; Map)
#EY $\overline{nnnnnnnnn}$	0 0 0 0 0 0 0	No	Doppler Param Source {c;d;h;p;r;s;t;u}
EZ $\overline{nnnnnn}$	EZ 10000010	Yes	Sensor Source (C;D;H;P;R;S;T; U)
ME	N/A	No	ErAsE recorder
MM	N/A	No	Show memory usage

Table 20. Pathfinder Commands and Defaults

Command	Default	Dynamic Command	Description
MN name	MN DVL_	No	Set file name [1..32 characters]
MR 0	0	No	Set recorder on/off [0=off,1=on]
MY	N/A	No	Y-Modem output
PA	N/A	No	Pre-deployment tests
PC	N/A	No	Display Pressure, Temperature, Heading, Pitch, Roll Built-in test
PC0	N/A	No	Help
PC2	N/A	No	Display Sensor Data
PC4	N/A	No	Display Voltage Monitor ADC Data
PC5	N/A	No	Display Leak Sensor ADC Data
PC20	N/A	No	Display Scrolling Sensor Data
PC40	N/A	No	Display Scrolling Voltage Monitor Data
PC50	N/A	No	Display Scrolling Leak Sensor ADC Data
PDn	PD0	No	Data stream select (0, 4, 5, 6, 13)
#PEnnnnn	#PE 00000	No	Ethernet Data Streams Bitmask (PD0,4,5,6,13)
PS0	N/A	No	Display System Configuration
PS1	N/A	No	Display fixed leader (binary).
PT0	N/A	No	Built-In test – Help
PT3	N/A	No	Built-In test - Receive Path
PT5	N/A	No	Built-In test - Transmit/Receive Continuity
PT9	N/A	No	Built-In test - Transmit Memory Test
PT10	N/A	No	Built-In test - Receive Memory Test
PT11	N/A	No	Built-In test - FRAM Test
PT12	N/A	No	Built-In test - RAM Test
PT13	N/A	No	Built-In test - ROM Test
PT14	N/A	No	Built-In test - Recorder Test
PT19	N/A	No	Built-In test - Ringing Test
TEhh:mm:ss.ff	00:00:00.00	No	Time per ensemble (hours:minutes:seconds.100 th of seconds)
TF --/--/--:--:--:--	N/A	No	Set First Ping Time (yy/mm/dd, hh:mm:ss)
TPmm:ss.ff	00:00.00	No	Time between pings (minutes:seconds.100 th of seconds)
TSyy/mm/dd, hh:mm:ss	N/A	No	Set real-time clock (year/month/day, hours:minutes:seconds)
TTccyy/mm/dd, hh:mm:ss	N/A	No	Set real-time clock (Y2k compatible) (century year /month/day, hours:minutes:seconds)
WAnnn, #WAnnn	050	Yes	False target threshold maximum (0 to 255 counts)
WBn	1	Yes	Bandwidth 0=Wide, 1=Narrow
WCnnn, #WCnnn	064	Yes	Correlation threshold (0 to 255 counts)
WDnnn nnn nnn	111110000	No	Data Out {v;c;a;p;s;*,*,*,*}
WEnnnn, #WEnnnn	2000	Yes	Error velocity threshold (0 to 5000 mm/s)
WFnnnn	0088	Yes	Blanking Distance [0 to 999 cm]
WJn, #WJn	1	Yes	BroadBand Receiver gain (0 = Low, 1 = High)
WNnnn	030	Yes	Number of Bins (1 to 255)
WPnnnn	000	Yes	Pings per ensemble (0 to 16384)
WSnnnn	0200	Yes	Bin size 10 to 800 cm
WTnnnn, #WTnnnn	0000	Yes	Transmit length (0 to 3200 cm)
WVnnn	0383	Yes	Ambiguity velocity (020 to 700 cm/s radial)
#WX n	0	Yes	Set Single Beam Xmit



Highlighted commands are “expert” commands. Changing these command parameters can have severe consequences to data collection.



Commands queried (e.g., B?) during an ensemble will, in general, cause the Pathfinder to respond with the usual description.



Editing or adding expert commands (#xx) to the command file will allow items to be set that if set incorrectly can cause the data to be the wrong format, bad, and/or uncorrectable even in post processing.

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 Pathfinder 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 to view. When the Pathfinder 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 <u>WP?</u> .
Examples	See below.

```
Pathfinder DVL
Teledyne RD Instruments (c) 2017
All rights reserved.
Firmware Version: 67.xx
```

```
>
```

```
>?
```

```
Available Commands:
```

```
# ----- Expert Commands
B ----- Bottom Track Commands
C ----- Control Commands
E ----- Environment Commands
M ----- Loop Recorder Commands
O ----- Feature Control
P ----- Performance Test Commands
T ----- Time Commands
W ----- Water Profiling Commands
? ----- Display Main Menu
```

```
>#p?
```

```
Available Commands:
```

```
#PD 0 ----- Data Stream Select, 0,4,5,6,13
#PE 00000 ----- Ethernet Data Streams Bitmask (PD0,4,5,6,13)
#P? ----- Display P-Command Menu
```


Break

Purpose	Interrupts Pathfinder without erasing present settings.
Format	<BREAK>
Description	A BREAK signal interrupts Pathfinder processing. It is leading-edge triggered and should last at least 300 ms. Pathfinder may respond to shorter breaks so care should be taken to avoid spurious signals on the communication lines. A BREAK initializes the system, sends a wake-up (copyright) message, and places the Pathfinder in the DATA I/O mode. The BREAK command does not erase any settings or data. Using <i>TRDI Toolz</i> , pressing the  icon in the lower left corner of the screen sends a BREAK.

Example <BREAK>

```
Pathfinder DVL
Teledyne RD Instruments (c) 2017
All rights reserved.
Firmware Version: 67.xx
```

>

Software Breaks can be used with *TRDI Toolz*. From the **Break** button drop down menu, select **Hard Break** or **Soft Break** (= = =) as needed for the DVL to wake up. If Soft Break is selected, the Pathfinder will use the "= = =" string instead of a break.

OI – Install Feature

Purpose This command is used to install features.

Format OI nnnxxxxxxxxxxxxxxxxxxxxxxxxxx

```
>OI
-----1-----2-----
Enter Code:
Code entered: ABBxxxxxxxxxxxxxxxxxxxx76
Features installed. Send <BREAK> to activate.
>
```

OL – Display Feature List

Purpose Lists the special firmware upgrades that are installed.

Format OL

Description Lists special features that are installed. See [Installing Firmware and Feature Upgrades](#) for information on how to install additional capability in the Pathfinder.

Examples See below.

```
>ol
FEATURES
-----
Feature                                     Installed
-----
Base Accuracy Bottom Track                 No
Water Profile                             Yes
High Accuracy Bottom Track                 Yes
Low-Altitude Bottom Track                 Yes
Ethernet Interface                         No
XRT Mode                                   Yes
```

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

>



Base Accuracy Bottom Track (Export-Compliant) and High Accuracy Bottom Track are mutually exclusive modes. Only one may be enabled.

Y – Display Banner

Purpose Displays the Pathfinder banner.

Format Y



Recommended Setting. Use as needed.

Description Displays the Pathfinder banner.

Example Y

```
>y
Pathfinder
Teledyne RD Instruments (c) 2017
All rights reserved.
Firmware Version: 67.xx
Current time is: 17/04/10,13:32:08.80
```

```
Ethernet detected: Yes
MAC Address is **.***.***.***.***
IP Address is ***.***.***.***
```

Bottom Track Commands

The Pathfinder system uses these commands for bottom-tracking applications. Bottom track commands tell the Pathfinder to collect speed-over-bottom data and detected range-to-bottom data. If the Pathfinder 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 (BP1) for Pathfinders. To turn OFF the bottom-tracking process, send a BPO command.

Available Bottom Track Commands

This section lists the available Bottom Track commands.

>b?

Available Commands:

```
BA 024 ----- Amplitude Threshold [0..255]
BB 0005 ----- Blanking distance (cm)
BC 220 ----- Correlation Threshold [0..255]
BE 1000 ----- Error Velocity Threshold [0-9999mm/s]
BF 00000 ----- Depth Guess [0=Auto, 1=MaxAlt dm]
BH 105,180 ----- Gain Switch Threshold (0-255cnts:lo;hi)
BI 005 ----- Gain Switch Altitude (meters)
BJ 100000000 ----- Data Out {t;c;*;h;r;n;*;*}
BK 0 ----- WMass Mode [0=off 1=WB 2=LostB 3=W]
BL 80, 160, 240 ----- WMass Params [min, near, far (dm)]
BM 8 ----- Bottom Mode [8,9,101]
BN 0,999 ----- Speed Log Hold/Drop Control
BO 025 ----- Distance Accum. Filter Tau (1/100ths)
BP 1 ----- Number of BT Pings in ensemble [0-999]
BQ -32768 ----- Set outvel when over range limit (mm/s)
BS ----- Clear Distance Traveled
BX 01100 ----- Max Depth (dm)
BY 20 ----- Transmit Length (pct)
BZ 1 ----- Low Altitude Mode [0=off, 1=ON]
B? ----- Display B-Command Menu
```

BP – Bottom-Track Pings per Ensemble

Purpose Sets the number of bottom-track pings to average together in each data ensemble.

Format BPnnn



The BP command works only without the # sign.

Range nnn = 0 to 999 pings

Default BP001



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

Description BP sets the number of bottom-track pings to average together in each ensemble before sending/recording bottom-track data.



The Pathfinder interleaves bottom track pings with water track pings, if water-mass layer mode is enabled, and with Profile pings if water profiling is enabled. If BP = zero, the Pathfinder will not collect bottom track data or water track data. Also, the Pathfinder will not collect water profile data if WP=0, or if the water profile feature is not enabled (see [TP – Time Between Pings](#), [WP – Pings Per Ensemble](#) and [BK - Water-Mass Layer Mode](#)).

The Pathfinder automatically extends the ensemble interval (TE) if BP x TP > TE (see [TE – Time Per Ensemble](#)).

BX – Maximum Tracking Depth

Purpose Sets the maximum tracking depth in bottom-track mode.

Format BXnnnnnn



The BX command works only without the # sign.

Range nnnnn = 3 to 1100 (600 kHz) decimeters (meters x 10)

Default XRT mode disabled: BX1100 (600 kHz)
XRT mode enabled: BX1600 (600 kHz)



Set BX to a depth slightly greater than the expected maximum depth.

Description The BX command sets the maximum tracking depth used by the Pathfinder during bottom tracking depending on if the Extended Range Tracking (XRT) mode is enabled or disabled (see the [OL command](#)). This prevents the Pathfinder from searching too long and too deep for the bottom, allowing a faster ping rate when the Pathfinder loses track of the bottom.

Example If 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 2900 dm. Now if the Pathfinder loses track of the bottom, it will stop searching for the bottom at 210-dm (21 m) rather than spend time searching down to 2900-dm (290 m).



The BX command limits the search range for bottom tracking. If the Pathfinder 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 Pathfinder 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.



In addition to limiting the search range, the BX command indirectly limits the bottom track range. While this does not prevent the Pathfinder from bottom tracking to ranges beyond the BX range, use caution in setting this command to less than the expected maximum depth as the Pathfinder will be less likely to hold a lock on the bottom if there is any slope beyond the BX range.

Expert Bottom Track Commands

This section lists the expert Bottom Track commands. Commands that start with the # sign are considered “expert” commands.

>#B?

Available Commands:

```
#B1 0 ----- Blank Range with Bad Velocity [0..1]
#B2 0 ----- Depth Memory Timeout [0=off, 1-30s]
#BA 024 ----- Amplitude Threshold [0..255]
#BB 0005 ----- Blanking distance (cm)
#BC 220 ----- Correlation Threshold [0..255]
#BE 1000 ----- Error Velocity Threshold [0-9999mm/s]
#BF 00000 ----- Depth Guess [0=Auto, 1=MaxAlt dm]
#BH 105,180 ----- Gain Switch Threshold (0-255cnts:lo;hi)
#BI 005 ----- Gain Switch Altitude (meters)
#BJ 100000000 ----- Data Out {t;c;*;h;r;n;*;*}
#BK 0 ----- WMass Mode [0=off 1=WB 2=LostB 3=W]
#BL 80,160,240 ----- WMass Params [min, near, far (dm)]
#BM 8 ----- Bottom Mode [8,9,10]
#BN 0,999 ----- Speed Log Hold/Drop Control
#BO 025 ----- Distance Accum. Filter Tau (1/100ths)
#BQ -32768 ----- Set outvel when over range limit (mm/s)
#BS ----- Clear Distance Traveled
#BY 20 ----- Transmit Length (pct)
#BZ 1 ----- Low Altitude Mode [0=off, 1=ON]
#B? ----- Display #B-Command Menu
```

#B1 - Blank Range with Bad Velocity

Purpose Sets the Bottom Track range to zero whenever velocity correlation drops below the minimum magnitude.

Format #B1 *n*



Correlation Magnitude Minimum is set via the CE or #CE command.

Range *n* = 0 to 1

Default #B1 0



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

Description #B1 allows for filtering out ranges when velocity shows a low correlation. This is especially useful when another system in the vicinity of the DVL is causing interference which mimics a Bottom Pulse but thanks to our velocity filtering ends-up with a low correlation when processed for velocity.

#B2 - Depth Memory Timeout

Purpose	Enables Bottom Track to preserve the range-to-bottom across a Break. #B2 0 (default) disables the feature. Setting #B2 to 1 to 30 sets a timeout, in seconds, after which the device will search for the bottom as normal.
Format	#B2 <i>n</i>
Range	<i>n</i> = 0, 1 to 30
Default	#B2 0



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

Description	# B2 sets a time during which the DVL can retain the last known good range when a Break is received followed by a CS command. This is especially useful as when sending a Break the DVL will search for the bottom in its default configuration, setting the #B2 allows to avoid searching for the bottom and thus benefits the user by offering a faster re-start post break. In addition, this command has proven very useful to prevent the DVL from locking onto interfering signals in noisy environments.
-------------	---

#BA - Evaluation Amplitude Minimum

Purpose	Sets the minimum value for valid bottom detection.
Format	#BA <i>nnn</i>



The BA commands work with or without the # sign. For example, using BA or #BA are both valid commands.

Range	<i>nnn</i> = 1 to 255 counts
Default	#BA24



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 – Bottom Blanking Interval

Purpose	This command sets the near limit of bottom detection beyond the transmit pulse.
Format	#BB <i>nnnn</i>



The BB commands work with or without the # sign. For example, using BB or #BB are both valid commands.

Range	<i>nnnn</i> = 0 to 3200
Default	#BB0005



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

Description	The Pathfinder will search for the bottom starting at the length of transmit plus this blanking interval.
-------------	---

#BC - Correlation Magnitude Minimum

Purpose Sets minimum correlation magnitude for valid velocity data.

Format #BCnnn



The BC commands work with or without the # sign. For example, using BC or #BC are both valid commands.

Range nnn = 0 to 255 counts

Default #BC220



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

Description Sets a minimum threshold for good bottom-track data. Any bottom-track data with a correlation magnitude less than this value will be flagged as bad.



A count value of 255 is a perfect correlation (i.e. solid target)

#BE - Error Velocity Maximum

Purpose Sets maximum error velocity for good bottom-track data.

Format #BEnnnn



The BE commands work with or without the # sign. For example, using BE or #BE are both valid commands.

Range nnnn = 0 to 9999 mm/s

Default #BE1000



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 Pathfinder uses this parameter to determine good bottom-track velocity data. If the error velocity is greater than this value, the Pathfinder 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, then the data is accepted since four good beams are needed for error velocity calculation.

#BF - Depth Guess

Purpose Sets a “best-guess” of expected bottom range for internal calculations.

Format #BFnnnnn



The BF commands work with or without the # sign. For example, using BF or #BF are both valid commands.

Range *nnnnn* = 1 to Maximum Altitude dm (0 = automatic)

Default #BFO



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

Description When set to a non-zero value, the Pathfinder transmits a fixed pulse based on a given bottom range. This is useful for applications with fixed range bottoms. The command reduces the amount of time the Pathfinder uses to search for the bottom if lost.

#BH – Gain Switch Threshold

Purpose Sets the RSSI thresholds for switching the receiver gain for a bottom track ping.

Format #BH *nnn*, *nnn* (lo;hi)

Range *nnn* = 0 to 255 counts

Default #BH 105,180



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

Description Receiver gain control for bottom track always uses low gain when the altitude over the sea bottom is less than the Gain Switch Altitude (set by the #BI command). When the altitude is above the Gain Switch Altitude:

- Switch to high gain when RSSI is below the low threshold set by the #BH command.
- Switch to low gain when RSSI is above the high threshold set by the #BH command.

Using two thresholds provides hysteresis, so that the gain does not need to switch on every ping when the RSSI is at some in-between level.

#BI - Gain Switch Altitude

Purpose Selects the maximum vertical distance from the transducer to the bottom at which the Pathfinder operates at low gain.

Format #BI*nnn*



The BI commands work with or without the # sign. For example, using BI or #BI are both valid commands.

Range *nnn* = 0 to 3 meters

Default #BI005



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.

#BJ – Data Type Output Control

Purpose: Bottom data types that will be output in the ensemble.

Format: Format #BJ *tc* hrn ****



The BJ commands work with or without the # sign. For example, using BJ or #BJ are both valid commands.

The High Accuracy Bottom Track feature must be installed for the #BJ command to be enabled (see [OL – Display Feature List](#)).

*: not used; reserved for future use (set to zero).

t: Standard bottom track output (see [Binary Bottom-Track Data Format](#))

c: Commands output (see [Bottom Track Command Output Format](#) for a definition of this data type)

h: High resolution bottom and water mass velocity and distance (note that this will cause distance to be accumulated). See [Bottom Track High Resolution Velocity Format](#) for a data type definition)

r: Range (corrected) output. See [Bottom Track Range Format](#) for a data type definition.

n: Precision Navigation Output. See [Navigation Parameters Data Format](#) for data type definition.

Range: 0 or 1 for each digit

Default: #BJ 100 000 000



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

Description: This command controls the data types that are output in the ensemble.



Include the spaces between the groups of three digits for readability. The command is accepted with or without spaces.

#BK - Water-Mass Layer Mode

Purpose: Selects the ping frequency of the water-mass layer ping

Format: #BK*n*



The BK commands work with or without the # sign. For example, using BK or #BK are both valid commands.

Range: *n* = 0 to 3

Default: BK0



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

Description: The BK command selects how often the Pathfinder performs a water-mass layer ping while bottom tracking. The number of water-mass layer pings per ensemble is dependent on the BP-command (see [BP – Bottom-Track Pings per Ensemble](#)) and this command setting. Use the #BL-command to set the location of the water-mass layer (see [BL - Water-Mass Layer Parameters](#)).

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
#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 #BLmmm,nnnn,ffff



The BL commands work with or without the # sign. For example, using BL or #BL are both valid commands.

Range *mmm* = Min Layer Size (1 to 640 decimeters) [meters x 10]
nnnn = Near Layer Boundary (0 to 9999 decimeters) [meters x 10]
ffff = Far Layer Boundary (0 to 9999 decimeters) [meters x 10]

In addition, the following must be true:

$$\text{Far} \geq (\text{Near} + \text{Min})$$

The Far boundary cannot exceed 80% of the range-to-bottom of the beam with the shortest altitude. If the bottom comes up so that the Far boundary does not meet this requirement, then the Far boundary is automatically adjusted to ensure this requirement is met, unless the minimum layer size cannot be maintained, in which case the water track ping is skipped and the data is marked bad.

Default #BL80,160,240



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

Description The #BL-command sets a water-mass layer. 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 (see [BK - Water-Mass Layer Mode](#)) and BP (see [BP – Bottom-Track Pings per Ensemble](#)) commands 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 Pathfinder sends Error Code 011.



For more information, see [Water Tracking](#), page 27.

#BM – Bottom Mode

Purpose: Sets the Bottom Track mode.

Format: #BM n



The BM commands work with or without the # sign. For example, using BM or #BM are both valid commands.

Range: $n = 8, 9, \text{ or } 101$

Default: #BM8



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

Description: Bottom Mode 8 was developed for the following improvements in shallow operations:

- Much improved accuracy by pinging Beams around, one at a time.
- Better handling of slopes by independently setting lags on each beam based on accurate bottom detection before each ping.
- Better handling of station keeping application using longer lag.
- Higher resolution Bottom Detection using short lag Bottom Feeler pings.

Table 22: BM8 Minimum Tracking Depths

Frequency	Min Tracking Depths	With Low Altitude feature
600KHz	0.2m	<20cm

Bottom Mode 9 is identical to Bottom Mode 8 except that it does not have a shallow mode.

#BM101 enables the Side-Lobe coupling test. Note that this command doesn't work in the non-# version of the menu, it's expert-only.

#BN - Speed Log Hold/Drop Control

Purpose: Controls the behavior of the distance measure calculation when Bottom Track is lost.

Format: #BN x,y



The BN commands work with or without the # sign. For example, using BN or #BN are both valid commands.

Range: $x = 0 \text{ to } 1$
 $y = 0 \text{ to } 999 \text{ seconds}$

Default: #BNo,999



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 PD6 data format when the Pathfinder can't get a lock on the bottom. The y parameter represents a timeout period during which zero is used for the current velocity measurement in the equation shown in the #BO command. After the expiration of the y timeout, the behavior is governed by the x parameter. If x is zero, then the accumulated distance is set to zero. If x is one, then the accumulated distance is maintained at its current value until the Pathfinder achieves bottom lock.

#BO - Distance Measure Filter Constant

Purpose: Sets the value of the filter constant used by the distance measurement calculation in PD6.

Format: #BO*k*



The BO commands work with or without the # sign. For example, using BO or #BO are both valid commands.

Range: $k = 0$ to 100

Default: #BO25



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

Description: When calculating the earth referenced distance data for output in the PD6 data format, the Pathfinder 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:

$$v = (k \cdot v_{\text{new}} + (100 - k) \cdot v_{\text{old}}) / 100$$

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.

#BQ – Over Range Limit



This command is only used for 38 kHz systems.

#BS - Clear Distance Traveled

Purpose: Clears internal distance traveled accumulators.

Format: #BS



The BS commands work with or without the # sign. For example, using BS or #BS are both valid commands.



Use as needed.

Description: Distance traveled is calculated and output in the following Pathfinder output formats;

- PD0 high resolution output (see [BJ – Data Type Output Control](#) and [Bottom Track High Resolution Velocity Format](#))
- PD5 (see [Pathfinder Binary Data Format \(PD5\)](#)).
- PD6 (see [Pathfinder Output Data Format \(PD6\)](#))

The accumulator is zeroed on <BREAK> or by using this command in the manual ensemble cycling mode (see [CF - Flow Control](#)).

#BY – Transmit Length

Purpose Scales the bottom mode transmit.

Format #BYnn



The BY commands work with or without the # sign. For example, using BY or #BY are both valid commands.

Range: nn = 0 to 100 %

Default: #BY20



The default setting for this command should never be changed without through testing, as changes to this parameter have the potential to produce incorrect velocity and/or range data.

Description The BY command sets the transmit length for a bottom track ping as a percentage of the altitude over the sea bottom. The default setting has been designed to optimize the tradeoff between energy consumption and the ability to detect the bottom with combined tilt/slope of up to about 15 degrees. Smaller values result in shorter transmits, which use less energy, but which may not fully ensonify the beam on the sea bottom, especially if the instrument is tilted or if the bottom has a slope, resulting in velocity bias. Larger values result in longer transmit pulses (up to a point) which may allow bottom detection at larger values of tilt/slope, but will consume more energy, and may decrease the resolution of the range-to-bottom measurement.

#BZ – Low Altitude Mode

Purpose Turns on or off the Low Altitude Bottom Track mode.

Format #BZn



The BZ command works only with the # sign.

Range: n = 0 to 1 (0 = OFF, 1 = ON)

Default: #BZ1



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

Description #BZ 0 turns off the Low-Altitude bottom function. #BZ 1 turns on the Low-Altitude bottom function.

Control System Commands

The Pathfinder uses the following commands to control certain system parameters.

Available Control System Commands

This section lists the available Control System commands.

>c?

Available Commands:

```
CB 811 ----- Serial Port Control {baud;parity;stop}
CE 1 ----- Enable Ethernet [0 = OFF, 1 = ON]
CF 11110 ----- Set Ctrl Flags {e;p;b;s;*}
CK ----- Save Command Parameters to Flash
CR ----- Restore Cmd defaults [0=user,1=factory, 2=Eth parms]
CS ----- Start Pinging
CT 0 10 ----- Turnkey [0 = Off, 1 = Serial, 2 = Ethernet, T = 5 to 100 (integer seconds)]
CX 0 0 65535 0----- Set Input Trigger [mode, dly, timeout, ping-once]
CZ ----- Put the ADCP to sleep
C? ----- Display C-Command Menu
```

CB - Serial Port Control

Purpose Sets the RS-232/422 serial port communications parameters (Baud Rate/Parity/Stop Bits).

Format CBnnn

Range nnn = baud rate, parity, stop bits (see description)

Default CB811



The Pathfinder defaults to CB811 (115200 baud) if this parameter has never been saved to non-volatile memory. Otherwise, it uses the value last saved (i.e. the last time a [CK command](#) was issued).

Description The Pathfinder can be set to communicate at baud rates from 1200 to 115200 (see [Changing the Pathfinder's Baud Rate](#)). The Pathfinder and the external device (dumb terminal, computer software) **MUST** use the same communication parameters to *talk* to each other. After entering a valid CB parameters, the Pathfinder responds with a ">" prompt. Then change the external device's communication parameters to match the Pathfinder parameters before sending another command.



If a BREAK is sent before changing the external device's communication parameters, the Pathfinder returns to the communication parameters stored in non-volatile memory (user settings).

Table 23: Serial Port Control

Baud Rate	Parity	Stop Bits
1 = 1200	1 = None (Default)	1 = 1 Bit (Default)
2 = 2400	2 = Even	2 = 2 Bits
3 = 4800	3 = Odd	
4 = 9600	4 = Low (Space, logical 0)	
5 = 19200	5 = High (Mark, logical 1)	
6 = 38400		
7 = 57600		
8 = 115200 (Default)		

CE – Enable Ethernet

Purpose	Use this command to check the IP address/settings.
Format	CE <i>n</i>
Range	0 to 1 (0 = OFF, 1 = ON)
Default	CE1



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

Description The CE command default is CE1 only if the Ethernet feature is activated. CE 1 will enable the Ethernet if it was switched off. CE0 will switch off the Ethernet. This command also reports whether Ethernet is functional based on verifying coms between the DSP circuit and the Ethernet module; this is done regardless of whether Ethernet feature is activated.

Example showing disconnected RJ45 Ethernet cable:

```
>CE
Ethernet Detected: Yes
Timed out waiting for response from Eth module
Ethernet ON
```

Example with connected RJ45 Ethernet cable:

```
>CE
Ethernet Detected: Yes
MAC Address is 00"90:C2:FA:A2:73
IP Address is 192.168.1.100 (Static)
Network Status: Up
Ethernet ON
```



You must have the RJ45 connector plugged into the network switch for the CE command to return the Ethernet setting info.

CF - Flow Control

Purpose	Sets various Pathfinder data flow-control parameters.
Format	CF <i>nnnnn</i>
Range	Firmware switches (see description)
Default	CF11110



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

Description The CF-command defines whether the Pathfinder: 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.

Table 24: 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 Pathfinder is not echoed. This feature manually controls ping timing within the ensemble. Note the prompt output by the Pathfinder when ready to ping is a less-than symbol (<), to distinguish it from the normal command prompt.
CFxx1xx	Binary Data Output – Sends the ensemble in binary format, if serial output is enabled.
CFxx0xx	Hex-ASCII Data Output – Sends the ensemble in readable hexadecimal-ASCII format, if serial output is enabled.
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.
Example	CF01010 selects manual ensemble cycling, automatic ping cycling, Hex-ASCII data output, and enables serial output.



When operating in HEX mode, all console text appears in HEX - including the prompt ">" (HEX "3E") and any additional commands that are typed.

CK - Keep Parameters

Purpose Stores present parameters to non-volatile memory.

Format CK



The CR1 command must be the first command sent to the Pathfinder. The CK command must be sent just before the CS command. Other commands may be sent in any order.

Description CK saves the present user command parameters to non-volatile memory on the CPU board. The Pathfinder maintains data stored in the non-volatile memory (user settings) even if power is lost. It does not need a battery. Use the CR command to recall parameters stored in non-volatile memory (see [CR – Retrieve Parameters](#)).

CR – Retrieve Parameters

Purpose Resets the Pathfinder command set to factory settings.

Format CRn

Range n = 0 (User), 1 (Factory), 2 (Eth parameters)



The CR1 command must be the first command sent to the Pathfinder. The [CK command](#) must be sent just before the CS command. Other commands may be sent in any order.

Description The Pathfinder automatically stores the last set of commands used in volatile memory. The Pathfinder will continue to be configured from volatile memory unless it receives a CR command or until the volatile memory loses its power.

Table 25: Retrieve Parameters

Format	Description
CR0	Loads into volatile memory the command set last stored in non-volatile memory (user settings) using the CK Command.
CR1	Loads into volatile memory the factory default command set stored in ROM (factory settings).
CR2	Loads into volatile memory the factory defaults Ethernet Settings stored in ROM (Ethernet Parameters).



The CR command keeps the present baud rate and does not change it to the value stored in non-volatile memory or ROM. This ensures the Pathfinder maintains communications with the terminal/computer.

CS – Start Pinging (Go)

Purpose Starts the data collection cycle (same as the **Tab** key).

Format CS



The CR1 command must be the first command sent to the Pathfinder. The [CK command](#) must be sent just before the CS command. The CS command is the last command sent.

Description Use CS (or the **Tab** key) to tell the Pathfinder system to start pinging its transducer and collecting data as programmed by the other commands.

CT - Turnkey Operation

Purpose Allows the Pathfinder to initialize to predefined parameters and start pinging within 5-100 integer seconds after power is applied, or a break is received, if no command is entered.

Format CT n T



The CT commands work with or without the # sign. For example, using CT or #CT are both valid commands.

Range n = 0 to 2 (0 = Off, 1 = Turnkey On-Output Serial, 2 = Turnkey On-Output Ethernet)
T = 5 to 100 (integer seconds)

Default CT 0 10



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

Description Setting the CT command to CT1 10 lets the Pathfinder automatically initialize to a predefined command set during any power up or after a break.

To place the Pathfinder in turnkey mode, first set all other commands to the desired configuration. Then send the CT1 10 and CK commands to save this configuration (see [CK - Keep Parameters](#)). When power is cycled or a break is sent, the Pathfinder will start up with the desired configuration and begin the data collection process unless a valid command is sent within 10 seconds.

Turnkey mode can be interrupted by sending a <BREAK>. This will place the Pathfinder in the command mode, ready to accept input for another 10 seconds. To turn off the turnkey mode, first send a <BREAK> to the Pathfinder. Now send the CTo and CK commands to save this configuration. When power is cycled or a break is again sent, the Pathfinder will NOT begin the data collection process.

CX – Input Trigger Enable

Purpose Enables or disables the trigger.

Format CX *n d t [p]*



Use as needed.

Range	<i>n</i>: <i>n</i> = 0 to 5 per Table 26. <i>d</i>: 0 to 65535 one hundredths of a second delay time. <i>t</i>: 0 to 65535 one hundredths of a second time-out time. Setting “<i>t</i>” to 65535 disables the time-out. <i>p</i>: (optional) 0 or 1. Setting “<i>p</i>” to 1 enables ping-once mode after time-out.
Default	CX 0 0 65535 0
Description	The unit will ping once within 1ms after the trigger transitions as indicated in Table 26 for CX = 1 to 3. For CX 4 to 5, the Pathfinder will trigger while the trigger is in the state described in Table 26. If “<i>p</i>” set to 1, ping only once after time-out, then wait again for another Trigger or time-out. If set to 0 (default) or is not set (legacy CX command), it will default to 0 and the DVL will self-deploy normally after time-out.

Table 26. Input Trigger

CX (<i>n</i>)	System Behavior
0	Trigger off
1	Pings after low to high transition
2	Pings after high to low transition
3	Pings after either low to high or high to low transition
4	Ping while trigger is low
5	Pings while trigger is high



The polarity is defined as the electrical level at the connector (J3) on the electronics enclosure (see Table 2).

Note that commanded time between pings (TP) takes higher precedence than this command. That is, the unit will ping on the next trigger after TP has been satisfied.

The trigger delay causes the unit to wait after a trigger is received for pinging to start. Delay after trigger is received is valid only for first ping for CX *n*=4 or 5.

The time-out is effective the first time the time-out occurs. The unit pings without waiting for the trigger after the first time-out.

De-asserting the trigger after it has been asserted and the ping started will not stop the ping for CX *n*=4 or 5. That is, the trigger condition only delays the ping prior to transmit and will not be checked until the Pathfinder unit is ready to transmit again.



Note that commanded time between pings (TP) takes higher precedence than this command. That is, the unit will ping on the next trigger after TP has been satisfied (see [TP – Time Between Pings](#)).



The Trigger In line must be referenced to D_COM (see [Cable Wiring Diagrams](#)).

CZ – Power Down ADCP

Purpose Tells the Pathfinder to power down.

Format CZ



Recommended Setting. Use as needed.

Description Sending the CZ command powers down the DVL and draws a minimal amount of current. Pathfinder processing is interrupted and the DVL goes in the STANDBY mode (RAM is maintained).

Example See below

```
>cz
```

Powering Down



A Hard Break will re-wake the unit. Note that this only works over serial, not Ethernet.



Only a Hard Break will wake up the DVL from sleep. Using a Software Break will not work.

Expert Control System Commands

This section lists the expert Control System commands. Commands that start with the # sign are considered “expert” commands.

```
>#C?
```

Available Commands:

```
#CT 0 ----- Turnkey [0 = OFF, 1 = ON]
```

```
#C? ----- Display #C-Command Menu
```

Environmental Commands

The Pathfinder 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?

Available Commands:

```
EA +00000 ----- Heading Alignment [.01 deg cw]
EC 1500 ----- Speed Of Sound [m/s]
ED 00000 ----- Xdcr Depth [dm]
EH 00000,1 ----- Heading {heading;frame}
EP +0000,+0000,1 ----- Tilts {pitch;roll;frame}
ER +0000 ----- Roll [.01 deg cw]
ES 35 ----- Salinity [ppt]
ET 2100 ----- Water Temperature [.01 deg C]
EU 0 ----- Orientation [0=Switch,1=Up,2=Down]
EV +00000 ----- Heading Bias [.01 deg cw]
EX 10111 ----- Coordinate Transformations
EZ 10000010 ----- Sensor Source {c;d;h;p;r;s;t;u}
E? ----- Display E-Command Menu
```

EA - Heading Alignment

Purpose Corrects for physical misalignment between Beam 3 and the heading reference.

Format EA±nnnnn



The EA command work ONLY without the # sign.

Range ±nnnnn = -17999 to 18000 (-179.99 to 180.00 degrees)

Default EA00000



Set as needed.

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 [EV - Heading Bias](#) command to correct for heading bias (e.g., magnetic declination).

Example The Pathfinder is mounted on a ship/vehicle with beam 3 aligned at a +45 degree angle (i.e. clockwise) from the forward axis of the ship/vehicle. Use the EA command to tell the Pathfinder 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:

$$EA = +45.00 \times 100 = +4500 = EA+04500$$

EC - Speed of Sound

Purpose	Sets the speed of sound value used for Pathfinder data processing.
Format	ECnnnn
Range	nnnn = 1400 to 1600 meters per second
Default	EC1500



The EC command works with or without the # sign. For example, using EC or #EC are both valid commands.



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

Description	EC sets the sound speed value used by the Pathfinder to scale velocity data, depth cell size, and range to the bottom. The Pathfinder 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 Pathfinder overrides the manually-set EC value and calculates speed of sound using the values determined by ED ([ED - Depth of Transducer](#)), ES ([ES - Salinity](#)), and ET ([ET - Temperature](#)). EZ also selects the source for ED, ES, and ET.

ED - Depth of Transducer

Purpose	Sets the Pathfinder transducer depth.
Format	EDnnnnn



The ED command work ONLY without the # sign.

Range	nnnnn = 0 to 65535 decimeters (meters x 10)
Default	ED00000



Use the EZ-command (see [EZ - Sensor Source](#)).

Description	ED sets the Pathfinder transducer depth. This measurement is taken from sea level to the transducer face. The Pathfinder uses ED in its speed of sound calculations. The Pathfinder 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 or 2, the Pathfinder overrides the manually set ED value and uses depth from the internal or external pressure sensor, respectively. If a pressure sensor is not available, the Pathfinder uses pressure data from the best available sensor or ED command.

EH - Heading

Purpose Sets the Pathfinder heading and the coordinate frame (instrument or ship) to which EH-command input refers.

Format EHxxxx, y



The EH command works with or without the # sign. For example, using EH or #EH are both valid commands.

Range xxxx = 0 to 35999 1/100ths of a degree

y = 0 for instrument coordinates

y = 1 for ship coordinates

Default EHo,0 (Stationary systems), EHo,1 (Vessel)



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

Description EH sets the Pathfinder heading and heading coordinate frame if both arguments are entered.

EH sets the Pathfinder heading if only one argument is entered. This heading value is assumed to be in instrument coordinates. Figure 17 shows transducer beam axis and tilt signs.

EH may be entered after the unit is commanded to ping (CS command) and will be used in subsequent pings.

Example Convert heading values of +21.5 degrees to EH-command values referenced to ship coordinates.

Heading in hundredths = $21.50^\circ \times 100 = 2150$
EH 2150, 1 (+ in front of 2150 is optional)



If the EZ Heading field = 1, the Pathfinder overrides the manually-set EH value and uses heading from the transducer's internal sensor. If the EZ Heading field = two the Pathfinder takes heading from an external synchro. If EZ Heading field is zero the Pathfinder uses the manual EH command settings.

See [EZ - Sensor Source](#) for more details and restrictions for the case of mixed heading sources.

EP - Pitch and Roll Angles

Purpose Sets the Pathfinder pitch (tilt 1) and, optionally, the roll (tilt 2) and the coordinate frame (instrument or ship) to which all pitch and roll inputs (including sensors) refer. Alternatively, the EP commands may be used with single arguments, in which case it is assumed that the pitch and roll inputs represent the pitch and roll of the instrument rather than those of the ship.

Format EP±xxxxx, ±yyyyy, z



The EP command works with or without the # sign. For example, using EP or #EP are both valid commands.

Range $\pm xxxxx$ and $\pm yyyyy = -17999$ to $+18000$ hundredths of a degree
 $z = 0$ for instrument coordinates,
 $z = 1$ for ship coordinates

Default EP0,0,1



Set as needed.

Description EP sets the Pathfinder pitch (tilt 1) and roll (tilt 2) and the pitch/roll coordinate frame if all three arguments are entered. EP sets the Pathfinder pitch (tilt 1) if only one argument is entered. This pitch value is assumed to be in instrument coordinates.

If only two fields are entered, a command entry error is issued. Figure 17 shows transducer beam axis and tilt signs.

Example Convert pitch and roll values of +14 degrees and -3.5 degrees to EP-command values referenced to ship coordinates.

Pitch in hundredths = $14.00 \times 100 = 1400$
 Roll in hundredths = $-3.50 \times 100 = -350$
 EP 1400, -350, 1 (+ in front of 1400 is optional)

ER - Roll Angle

Purpose Sets the Pathfinder roll angle that will be used by the system if the corresponding EZ bit is set to 0.

Format ER±nnnnn



The ER command works with or without the # sign. For example, using ER or #ER are both valid commands.

Range $\pm nnnnn = -17999$ to $+18000$ hundredths of a degree

Default ERO



Set as needed.

Description This command allows the user to input a roll (tilt 2) value that will be used if the roll EZ bit is set to zero. The coordinate frame of this data corresponds to the third parameter of the EP command. Roll can also be entered with pitch and the pitch/roll coordinate frame in the EP command (see [EP - Pitch and Roll Angles](#)). See the description of the EZ command ([EZ - Sensor Source](#)) to see how this commands value is used.

Example Convert roll values of +14 and -3.5 to ER command values.

#ER = $14.00 \times 100 = 1400 = \#ER01400$ (+ is understood)
 #ER = $-3.50 \times 100 = -350 = \#ER-00350$

ES – Salinity

Purpose Sets the water's salinity value.

Format ESnn



The ES command work ONLY without the # sign.

Range nn = 0 to 40

Default ES35



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

Description The ES command sets the water's salinity value. The Pathfinder uses ES in its speed of sound calculations. The Pathfinder assumes the speed of sound reading is taken at the transducer head.

ET - Temperature

Purpose Sets the water's temperature value.

Format ET±nnnn



The ET command works with or without the # sign. For example, using ET or #ET are both valid commands.

Range ±nnnn = -500 to 4000 (-5.00 C to +40.00 C)

Default ET2100



Use the EZ-command (see [EZ - Sensor Source](#)).

Description ET sets the temperature value of the water. The Pathfinder uses ET in its speed of sound calculations (see the primer). The Pathfinder 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 Pathfinder overrides the manually set ET value and uses temperature from the transducer's temperature sensor. If the sensor is not available, the Pathfinder uses the manual ET setting.

EU - Up/Down Orientation

Purpose Sets the Pathfinder up/down orientation.

Format EU n



The EU command works with or without the # sign. For example, using EU or #EU are both valid commands.

Range $n = 0$ or 1 ($0 = \text{down}$, $1 = \text{up}$)

Default EU 0



Use the EZ-command (see [EZ - Sensor Source](#)).

Description In conjunction with the EZ command, EU is used to manually specify the orientation of the Pathfinder.



The EU command can be used to align an upward pointing unit (e.g., mounted on a submarine) if the roll source is in instrument coordinates. In this case, the EU command will invert instrument coordinate roll. Use the #EI command instead if the roll source is referenced to ship coordinates (see [EI - Roll Misalignment Angle](#)).

EV - Heading Bias

Purpose Corrects for electrical/magnetic bias between the Pathfinder heading value and the heading reference.

Format EV $\pm nnnnn$



The EV command works with or without the # sign. For example, using EV or #EV are both valid commands.

Range $\pm nnnnn = -17999$ to 18000 1/100ths of a degree

Default EV 0



Set as needed.

Description EV is the heading angle that counteracts the local bias or magnetic variation (declination) between the Pathfinder and the heading source. EV is added to heading (either in ship or instrument coordinates) for use in velocity transformation and ensemble output.

Use the EA-command to correct for physical heading misalignment between the Pathfinder and a vessel's centerline (see [EA - Heading Alignment](#)).

Examples

1. A Pathfinder system is receiving heading from a compass. A magnetic variation chart for the deployment area shows a variation of W3.5 (-3.5). To counteract the effects of this magnetic field, enter a heading bias value of -3.5. To convert -3.5 to a EV-command value, multiply the desired bias angle in degrees by 100: $EV = -3.5 \times 100 = -350 = EV-350$.
2. Magnetic maps (such as NOAA) usually provides these types of reading: $10^{\circ}10'W$ 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 EV command value to EV-926.

EX – Coordinate Transformation

Purpose Sets the coordinate transformation processing flags.

Format EXxxptb



The EX command work ONLY without the # sign.

Range xx = Transformation
p = Pitch and Roll
t = 3 beam solutions
b = Bin mapping

Default EX10111



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.



For more information on coordinate transformations, see [Beam Coordinate Systems](#), page 29.

Table 27: 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 Pathfinder. Heading/Pitch/Roll not applied.
EX10xxx	Ship coordinates (Note 1) X, Y, Z vectors relative to the ship. Heading not applied. EA-command used, but not the #EV-command. If Bit 3 of the EX-command is a 1, then Pitch/Roll applied.
EX11xxx	Earth coordinates (Note 1) East, North, Vertical vectors relative to Earth. Heading applied. EA and #EV-commands used. If Bit 3 of the EX-command is a 1, then Pitch/Roll applied.
EXxx1xx	Use tilts (pitch and roll) in transformation (Note 2)
EXxxx1x	Allows 3-beam solutions if one beam is below the correlation threshold set by WC
EXxxxx1	Allow bin mapping (see Note 3)



1. For ship and earth-coordinate transformations to work properly set the Heading Alignment ([EA - Heading Alignment](#)) and Heading Bias ([EV - Heading Bias](#)) correctly. Ensure that the tilt and heading sensors are active ([EZ - Sensor Source](#)).
2. Setting EX bit 3 (Use Tilts) to 0 collects tilt data without using it in the ship or earth-coordinate transformations.
3. TRDI outputs the 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 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.

EZ - Sensor Source

Purpose Selects the source of environmental sensor data.

Format EZcdhprstu



The EZ command work ONLY without the # sign.

Range Firmware switches (see description)

Default EZ 10000010



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

Description Setting the EZ-command firmware switches tells the Pathfinder to use data from a manual setting or from an associated sensor. When a switch value is nonzero, the Pathfinder overrides the manual E-command setting and uses data from the appropriate sensor. If the sensor specified by this command is not available, the best alternate sensor will be used (see the [EY – Sensor Source Override for Doppler Parameters](#) command for more information).

The following table shows how to interpret the sensor source switch settings.

Table 28: Sensor Source Switch Settings

FIELD		VALUE = 0	VALUE = 1	VALUE = 2
C	Speed of sound	Manual #EC (see EC - Speed of Sound)	Calculates using available depth, salinity and temperature.	External Speed of Sound Sensor
D	Depth	Manual ED (see ED - Depth of Transducer)	Not Allowed	External Depth Sensor
H	Heading	Manual #EH (see EH - Heading)	Not Allowed	External Compass
P	Pitch (tilt 1)	Manual #EP (see EP - Pitch and Roll Angles)	Not Allowed	External Compass
R	Roll (tilt 2)	Manual #ER (see ER - Roll Angle)	Not used (Roll source specified by Pitch field)	Not used (Roll source specified by Pitch field)
S	Salinity	Manual ES (see ES – Salinity)	Not Allowed	External Salinity Sensor
T	Temp	Manual #ET (see ET - Temperature)	Internal transducer sensor	External Temp Sensor
U	Up/Down Orientation	Manual #EU (see EU - Up/Down Orientation)	Not Allowed	Not Allowed

Example EZ10000010 means calculate speed of sound from available depth salinity and temperature, use ED depth, EH heading, ES command sets salinity, TRDI internal temperature sensor, manual up/down orientation set with the EU command.



When a PS1-command is sent, the displayed Fixed Leader data shows the available internal sensors connected to the Pathfinder DVL. It does not show external sensors. To interpret this PS1 field, convert the value to binary.

If EZ pitch is one (internal sensor), a pendulum pitch correction will be applied that removes the effect of roll on pitch. This effect is common to most tilt sensors (electrolytic tilt and pendulum).

The pitch field of the EZ command controls the source for roll. The roll field is ignored and has only been retained for legacy purposes.

The heading coordinate frame is determined by the coordinate frame parameter of the #EH command for any heading source (command, internal or external). The pitch and roll coordinate frame is specified by the coordinate frame parameter of the #EP command for any heading source (command, internal or external). See [EH - Heading](#) and [EP - Pitch and Roll Angles](#) for more details.

Expert Environmental Commands

This section lists the expert Environmental commands. Commands that start with the # sign are considered “expert” commands.

>#E?

Available Commands:

```
#EC 1500 ----- Speed Of Sound [m/s]
#EE 0000010 ----- Rsrvd[4]; Cmd[1]; Rw/Nm[1]; Snsr Out[1]
#EH 00000,1 ----- Heading {heading;frame}
#EI +00000 ----- Roll Misalignment Angle [.01 deg cw]
#EJ +00000 ----- Pitch Misalignment Angle [.01 deg cw]
#EP +0000,+0000,1 ----- Tilts {pitch;roll;frame}
#ER +0000 ----- Roll [.01 deg cw]
#ET 2100 ----- Water Temperature [.01 deg C]
#EU 0 ----- Orientation [0=Switch,1=Up,2=Down]
#EV +00000 ----- Heading Bias [.01 deg cw]
#EY 0 0 0 0 0 0 0 0 ----- Dplr Param Override Src {c;d;h;p;r;s;t;u}
#E? ----- Display #E-Command Menu
```

#EE - Environmental Data Output

Purpose Controls output of specialized data types; controls whether a transform of velocity data to raw or nominal beam is done with associated corrections in the case of the phased array system.

Format #EE *abcdefgh*



The #EE command must be sent with the # sign.

Range Firmware switches (see description)

Default #EE 0000010



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

Description Bits “a” and “b” reserved for future use.

Bits *c* and *d* are reserved for future use.

Bit *e* controls the output of Environmental Command Parameters.

Bit *e* = one causes this data type to be output. See [Environmental Command Parameters Output Format](#) for a description of this data type.

Bit *f* signifies the use of the Phased Array transducer. For Phased Array systems, bit *f* controls the type of correction performed on the beam velocity data. For phased arrays, setting bit *f* to one applies the following corrections for all coordinate transforms of all ping types:

- Speed of Sound correction to vertical component
- Phase slope error due to vertical component.

Setting bit *f* to one also results in nominal 30° beam coordinate velocities output in the ensemble, and apply the system Beam correction matrix to correct for Beam pointing errors and hence output velocities in nominal 30° Beam coordinate system.

Setting bit *f* to zero results in raw beam velocities output in the ensemble and no Speed of sound or Phase Slope corrections applied.

Bit *g* controls the output of a data type with sensor source for parameters needed for Doppler calculations. This data indicates what sensors data were used for parameters of the Doppler calculation. This may be different than that specified by the EZ ([EZ - Sensor Source](#)) and EY ([EY – Sensor Source Override for Doppler Parameters](#)) commands depending on whether a sensor failed. Setting bit *g* to one causes this data type to be output. See Table 46 for a definition of this data type.

Correction for vertical speed of sound for Phased Arrays

Bit ‘f’ of the #EE command **must** be set to 1 for the firmware to do the internal computations required to output the correct horizontal and vertical velocities.

If the user has set a fixed speed of sound for their phased array DVL using EZ and EC (or using the default of 1500 for EC) and wants to correct the vertical velocity using the actual speed of sound, the correction formula is

$$V_{actual} = V_{output} * \frac{\sqrt{\frac{1}{C_{user}^2} - \frac{1}{4C_0^2}}}{\sqrt{\frac{1}{C_{actual}^2} - \frac{1}{4C_0^2}}}$$

Where

C_{user} is the fixed speed of sound that was set by the user

$C_0 = 1536\text{m/s}$

C_{actual} is the speed of sound from a SOS sensor or computed from measured temp and salinity

V_{output} is the vertical velocity output by the DVL

For $C_{user} = 1500$ and $C_{actual} = 1450$ the correction factor is 0.9569 while the ratio of the speeds of sound would give 0.9667 and error of 1% for the corrected speed of sound if the ratio were used instead of the above equation.

Derivation:

By design, for our phased array ADCPs, the actual beam angle in the water is given by

$$\sin(\theta) = \frac{c}{2c_0}$$

Where $c_0 = 1536\text{meters/sec}$.

Therefore

$$\cos(\theta) = \sqrt{1 - \sin^2(\theta)} = \sqrt{1 - \left(\frac{c}{2c_0}\right)^2}$$

If velocity is purely vertical, the velocity solution for a given Doppler frequency f_d is given by

$$v = \frac{f_d * c}{2f_0 \cos(\theta)} = \frac{f_d * c}{2f_0 \sqrt{1 - \left(\frac{c}{2c_0}\right)^2}} = \frac{f_d}{2f_0 \sqrt{\frac{1}{c^2} - \frac{1}{4c_0^2}}}$$

Where f_0 is the system frequency.

Taking the ratio of two vertical velocity solutions determined using different values for c obtains the equation at the top.

Vertical Range correction for Phased Arrays:

If the user setup for using manual SoS, i.e. using EC instead of sending in the actual SoS or instead of having the DVL calculate the SoS, then the equation for correcting altitude is:

$$R_{Corrected} = R_{Raw} * \frac{2}{\sqrt{3}} * \sqrt{\left(1 - \left(\frac{C_{actual}}{2 * C_{user}}\right)^2\right)}$$

Where

C_{user} is the fixed speed of sound that was set by the user

C_{actual} is the speed of sound from a SoS sensor or computed from measured temp and salinity

R_{Raw} is the vertical range to bottom obtained by the averaging the 4 vertical ranges to the bottom from DVL ('vertical' here means DVL vertical axis, i.e. not tilt corrected)

#EI - Roll Misalignment Angle

Purpose Corrects for a physical roll-like misalignment between the x-axis of the instrument and the ship's starboard axis.

Format #EI±nnnnn



The #EI command must be sent with the # sign.

Range ±nnnnn = -17999 to 18000 1/100ths of a degree

Default #EI0



Set as needed.

Description #EI is a rotation about the ship's forward axis. It is defined as the roll of the ship when the instrument is level.

For systems that have a roll source referenced to ship coordinates (typical for vehicles), use #EI to set the amount of rotation that the instrument's x-axis is physically offset from the ship's starboard axis. For such systems, the #EI command can also be used to align an upward pointing unit (e.g., mounted on a submarine) to the ship's axis by setting it to 18000.

For systems that have attitude referenced to internal coordinates, #EI is typically set to zero since the velocity data is referenced to either beam, instrument or geographic coordinates instead of ship coordinates.

For an upward pointing unit with instrument referenced attitude, use EU to align the instrument attitude data with the ship coordinates for use in velocity transformation.

#EJ - Pitch Misalignment Angle

Purpose Corrects for a physical pitch-like misalignment between the y-axis of the instrument and the ship's forward axis.

Format #EJ±nnnnn



The #EJ command must be sent with the # sign.

Range ±nnnnn = -17999 to 18000 1/100ths of a degree

Default #EJo



Set as needed.

Description #EJ is a rotation about the ship's starboard axis. It is defined as the pitch of the ship when the instrument is level.

For systems that are fixed in place on a moving vessel and that have an external pitch source or an internal pitch source, use #EJ to set the amount of rotation that the instrument's y-axis is physically offset from the ship's forward axis.

For systems that are stationary and have an internal compass, #EJ is typically set to zero since the velocity data is referenced to either beam, instrument or geographic coordinates instead of ship coordinates. However, a non-zero value may be used if ship attitude output data is desired for other purposes (see [EE - Environmental Data Output](#)).

Recorder Commands

The recorder contains approximately 16 megabytes of solid-state nonvolatile memory, which can be used to continuously record data. Once the recorder is full, it will stop recording data. The recorder is intended to be used on the Pathfinder for troubleshooting purposes during commissioning and integration of the system.

>M?

Available Commands:

```
ME ----- ErAsE recorder
MM ----- Show memory usage
MN DVL_ ---- Set file name [1..32 characters]
MR 0 ----- Set recorder on/off [0=off,1=on]
MY ----- Y-Modem output
M? ----- Display M-Command Menu
```

Recorder Command Descriptions

This section lists the Recorder commands.

ME – Erase Recorder

Purpose Erase the contents of the recorder.

Format ME ErAsE



Use as needed.

Description ME ErAsE erases the recorder memory. To make it more difficult to accidentally erase the data, the word “erase” must be typed with exactly one space after the “ME” (which is not case sensitive) and with alternating upper and lower case letters, as shown.

```
>ME ErAsE
[ERASING...]
```



Once erased, data is not recoverable.

MM – Show Memory Usage

Purpose Shows recorder memory usage.

Format MM



Use as needed.

Description Shows memory usage and the number of used and free pages.

```
>MM
Recorder Usage: used = 0, free = 16777216
```

>

MN – Set File Name

Purpose	Sets the file name for the recorder.
Format	MN xxx
Range	xxx = file name up to 32 characters long
Default	MN DVL_



Use as needed.

Description The MN command sets the deployment name to be used for any future deployments. The deployment name can be up to 32 characters long, and may contain letters, numbers, or the underscore (i.e. “_”) character. If no deployment name is specified a default of “DVL_” is used. The deployment name is used as part of the file name for data files when downloaded to the computer using *TRDI Toolz*.

In order to prevent data files on the computer from being overwritten, a ten-digit time stamp is appended to the file name when **OK** is clicked on the **Download Directory** dialog box.

For example, the file *Pathfinder3281997475.000* would contain data for the deployment named “Pathfinder” (the 3281997475 in the filename is the number of seconds since January 1st, 1900). The file extension is always “.000”. Waiting 25 seconds and downloading the same data again, the file name will change to *Pathfinder3281997500.000*.

MR – Set Recorder On/Off

Purpose	Turns the recorder on or off.
Format	MRn
Range	n = 0, turn recorder off; n = 1, turn recorder on
Default	MRO



Use as needed.

Description Use the MR command to turn the recorder on/off.

MY – Y-Modem Output

Purpose	Uploads recorder data to a host computer using standard YMODEM protocol.
Format	MY



Use *TRDI Toolz* to recover data.

Description Use the MY command to recover data from the recorder only when *TRDI Toolz* is not available to recover the data.

The MY command 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 DOS files.

Performance and Testing Commands

The Pathfinder uses the following commands for calibration and testing.

Available Performance and Testing Commands

This section lists the available Performance and Testing commands.

>P?

Available Commands:

```
PA ----- Run Go/No-Go Tests
PC ----- Built In Tests [0=help]
PD 0 ----- Data Stream Select [0,4,5,6,13]
PS ----- System Info [0=config,1=fldr,3=xform]
PT ----- Built-in-Test Commands [PT0=help]
P? ----- Display P-Command Menu
```

PA – Run Go/No-Go Tests

Purpose Sends/displays results of a series of system diagnostic tests.

Format PA

Range N/A

Default N/A

Description These diagnostic tests check the major modules and signal paths. TRDI recommends running this command before a deployment. These tests check non-volatile memory and ROM of the processor board. Also, the transmit and receive circuitry is tested using the PT3 and PT5 tests, respectively. See [PT3 – Receive Test](#) and [PT5 – Transmit/Receive Continuity Check Test](#) for more details.



Submerge the transducer face in a few inches of water when running the PA test. **The test may fail in air and if so, is not relevant.** Only a failure with the transducer at a minimum in contact with water is a relevant test.

Example See below

```
>pa
ROM Test...PASS [ 3aad ]
RAM test...PASS
FRAM test...PASS
Receive Buffer Test...PASSED
XMIT RAM Test...PASSED
Receive Path Test (Hard Limited)...PASSED
Transmit/Receive Continuity Check...PASSED
Recorder test.....PASS
```

Composite Result:
GO for Deployment



The PA test takes a little over 10 minutes to run, since it includes the PT14 recorder test.

PC - Built-In Tests

Purpose	Allow the user to view the values of sensor data used in Doppler processing and to identify the source of the data IDs.
Format	PCnnn
Range	nnn = 0, 2, 20, 4, 40, 5, 50
Description	PC0 displays the help menu. PC1 and PC3 are reserved for TRDI use. PC2 continuously displays at approximately 1 sec update the current system temperature, pressure, depth, heading, pitch and roll. The sensor ID corresponding to their source is displayed next to each. Refer to the EY command for a list of sensors. The source of the data is assigned by the EZ and the EY commands or internal logic if the primary sensor is not available. See EY – Sensor Source Override for Doppler Parameters for a description of that logic. PC4 displays the input power information.
Example	See below.

PC2 or PC20

The PC2 test updates the data inline using cursor commands, and the PC20 test performs the same test, but output the data in a line-by-line fashion to accommodate terminals that do not properly support cursor commands.

```
>pc2
Sensor data is sampled and displayed in a loop.
The number to the right of each backslash indicates the ID of the
  sensor used for that data.
Press any key to exit the loop.

  Temp(degC)  Press(kPa)  Depth(m)  Hdg(deg)  Pitch(deg)  Roll(deg)  Vin
/  24.94/10   99.063/10   10.104/10  0.00/0    0.18/10    0.59/10    47.58

>
```



This test can be run on the bench, on deck, or in water.

PC4 or PC40

The PC4 test updates the data inline using cursor commands, and the PC40 test performs the same test, but output the data in a line-by-line fashion to accommodate terminals that do not properly support cursor commands.

```
>pc4
Battery ADC data is sampled and displayed in a loop.
Press any key to exit the loop.

Count Chan0 Chan1 Chan2 Chan3 Chan4 Chan5 Vbatt Ibatt VDD1 VDD3 Vlsu Vls1
/  4  05c6  0428  068f  0095  0d31  0b82  20.58  2.046 1.64  0.09  2.06  1.80

>
```



See Table 34: Variable Leader Data Format, bytes 35 to 42 for a description of the ADC channels.

PC5 or PC 50

The PC5 test updates the data inline using cursor commands, and the PC50 test performs the same test, but output the data in a line-by-line fashion to accommodate terminals that do not properly support cursor commands.

```
>pc50
Leak detector ADC data is sampled and displayed in a loop.
Press any key to exit the loop.
DetA   DetB
0dc0   0008
0dc1   0007
0dc2   0004
>
```

The leak sensor status can be decoded as follow:

- 1- Convert hex ascii to decimal. For example:
 - a. DetA(hex) 0dc0 → to dec = 3520
 - b. DetB(hex) 0008 → to dec = 8
- 2- Convert these values to Voltages by x2.5 and /4095. For example:
 - a. DetA(hex) $3520 * 2.5 / 4095 = 2.14$
 - b. DetB(hex) $0008 * 2.5 / 4095 = 0.0048$
 - c. Compare the Values to the threshold shown below to determine leak status:



Leak	No Leak	Sensor Not Connected
Less than 1.25 Volts	1.25 to 2.3 Volts	Greater than 2.3 Volts

In our example above, Leak Sensor A is operating properly and did not detect a leak while Leak Sensor B is detecting a leak.

PS – Display System Parameters

Purpose Displays Pathfinder system configuration data.

Format PS*n*

Range *n* = 0, 1, 3 to 5

PS0 – System Configuration Info

```
>ps0
Serial Number: 600006
Frequency: 614400 Hz
Configuration: DVL : 4-beam velocity.
Transducer Type: PHASEDARRAY
Beam Angle: 30 Degrees
Beam Pattern: CONVEX
Sensors: TEMP
CPU Firmware: 67.14
FPGA Version: 1.00.012 [0x100c]
```

```
Board Serial Number Data:
C5 00 00 08 A2 76 08 28 DS18B20 TMP SNS
2A 00 00 02 86 C7 02 23 XDR72B-1110-00C
05 00 00 02 6D 56 EA 23 ETH72B-2305-00B
4B 00 00 02 6E D2 61 23 DSP72B-2303-00A
62 00 00 02 6E D8 7B 23 PTX72B-2304-03A
74 00 00 02 62 26 7B 23 RCV72B-2302-03A
```

PS1 – Display Fixed Leader (binary)

PS1 sends the Fixed Leader parameters (i.e., fixed system commands and hardware/firmware information) in Hex-ASCII or binary format with the Least Significant Byte (LSB) first (see [Fixed Leader Data Format](#)). For example, a Hex-ASCII output may look like this:

```
>PS1
3B00001C0D4C21003502320A001900190001480300E8030000320A941100007D2D3D0023000101FF000C000
000000000000000000000000DC12000019143E
```



The output format of the PS1 command is determined by the CF command (see [CF - Flow Control](#)).



When operating in HEX mode, all console text appears in HEX - including the prompt ">" (HEX "3E") and any additional commands that are typed.

PS3 – Instrument Transformation Matrix

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

```
>ps3
Instrument Transformation Matrix:
  1.004537   -1.004879   0.005736   -0.006243
  0.007302   -0.005948  -1.000888   0.996154
  0.289602   0.288031   0.286187   0.290252
 -0.707468  -0.707612   0.706830   0.711150
```

>

PS4 – Ping Sequence

This command returns the Bottom Track and Water profile ping sequence (see example below). Send PS4 to the Pathfinder anytime to get the ping sequence for one ensemble:

```
Pathfinder DVL
Teledyne RD Instruments (c) 2017
All rights reserved.
Firmware Version: 67.xx
```

>

```
>B?
Available Commands:
```

```
BK 0 ----- WMass Mode [0=off 1=WB 2=LostB 3=W]
BP 1 ----- Number of BT Pings in ensemble [0-999]
BX 06500 ----- Max Depth (dm) [10-65535 dm]
B? ----- Display B-Command Menu
```

```
>ps4
Ping Sequence:  B
```

```
>WP1
>ps4
Ping Sequence:  WB
```

```
>BP2
>ps4
Ping Sequence:  B WB
```

```
>WP2
>BP1
>ps4
Ping Sequence:  W WB
```

>

‘W’ stands for one single Water Profiling ping and ‘B’ stands for one single Bottom Tracking ping.

PS5 - Health and Environment Monitoring Sensors

The PS5 command reports the value of HEM operating time sensor.

PS5

Operating time: 4327.5 hours

PT – Diagnostic Tests

Purpose Displays results of the system diagnostic tests.

Format PT nnn

Range $n = 0$ to 200

Description See below

PT0 - Help

The PTO command displays the test menu (shown below). As implied by the NOTE, adding 100 to the test number repeats the test continually until the Pathfinder receives a <BREAK>. Sending PT200 runs the PT3 and PT5 tests. PT300 runs the PT3 and PT5 tests continually until the Pathfinder receives a <BREAK>.

Example:

```
>pt0
Built In Tests
-----
PT0  = Help
PT3  = Receive Path Test
PT5  = Transmit/Receive Loop Test
PT9  = Transmit Memory Test
PT10 = Receive Memory Test
PT11 = FRAM Test
PT12 = RAM Test
PT13 = ROM Test
PT14 = Recorder Test
PT19 = Ringing Test
```

PT3 – Receive Test

This test displays receive path characteristics. This test must be done with the transducer in water.



Submerge the transducer face in a few inches of water when running the PT3 test. **The test may fail in air and if so, is not relevant.** Only a failure with the transducer at a minimum in contact with water is a relevant test.

Example:

```
>pt3
Receive Path Test (Hard Limited):
      H-Gain W-BW      L-Gain W-BW      H-Gain N-BW      L-Gain N-BW
Correlation Magnitude (percent)
Lag Bm1 Bm2 Bm3 Bm4   Bm1 Bm2 Bm3 Bm4   Bm1 Bm2 Bm3 Bm4   Bm1 Bm2 Bm3 Bm4
0 100 100 100 100     100 100 100 100     100 100 100 100     100 100 100 100
1  80  84  82  81       81  83  80  82       82  82  79  81       83  80  80  82
2  42  46  49  48       44  49  43  47       47  46  41  46       52  42  45  46
3  15  18  23  24       25  22  14  24       22  13  13  17       26  15  16  18
4   6   0  10  10       22  10   6  15        4  12   2   1       10   8   4   4
5   5   6   9   4       15   4  11   7        7  13   9  11        2   9   7   2
```

```

6 4 11 9 2 11 6 14 6 7 11 8 11 6 6 7 3
7 5 13 6 6 11 7 13 8 5 13 10 11 7 1 5 5
P P P P
Sin Duty Cycle (percent)
50 49 42 43 47 47 47 43 53 49 51 53 49 46 45 50
P P P P
Cos Duty Cycle (percent)
49 53 50 43 49 52 48 45 48 54 49 54 51 52 50 51
P P P P
RSSI Noise Floor (counts)
54 60 69 58 38 43 53 42 65 72 80 69 43 48 58 47
P P P P
RESULT...PASSED

```

PT3 is considered to have normal values if:

1. Correlation at the last lag is less than 25%.
2. The duty cycle of sine and cosine does not vary from 50% by more than +/-15%.
3. RSSI noise level is less than 90 counts for the high gain, wide bandwidth setting.

PT5 – Transmit/Receive Continuity Check Test



Submerge the transducer face 2 to 4cm in water with at least 10cm between the face of the transducer and the bottom when running the PT5 test.

The test may fail in air and if so, is not relevant. Only a failure with the transducer at a minimum in contact with water is a relevant test.

The PT5 test is used to ensure continuity to the transducer and attempts to verify both transmit and receive pathways.

Example:

```

Transducer Continuity Check:
Beams 1,2: pass
Beams 3,4: pass

```

PT5 has an optional parameter:

- 1 = verbose mode
- o/no character = standard mode

Verbose mode 600 kHz:

```

>PT5 1
Transducer Continuity Check:
600Khz criteria 13 < R (ohms) < 24
Beams 1,2: V: 19.88 (volts) I: 3.69 (amps) R: 21.0 (ohms) PASS <FAIL>
Beams 3,4: V: 19.88 (volts) I: 3.69 (amps) R: 21.0 (ohms) PASS <FAIL>
>

```

PT9 - Transmit Memory Test

The PT9 test performs a write/read test of each memory location in the transmit RAM, which is used to hold the signal pattern that is transmitted during a ping.

```

>pt9
XMIT RAM Test....PASSED

```

PT10 - Receive Memory Test

```

>pt10
Receive Buffer Test...PASSED

```

PT11 - FRAM Test

The PT11 command performs the following tests of the FRAM (used to store recorder directory information):

- **Pattern Test:** Writes 4 patterns to each address in the FRAM space, and reads back from these addresses to make sure the data was correctly written.
- **Address Test:** This tests the address bus by writing consecutive number to addresses that have only 1 bit set (i.e. write 1 to 0x00000001, then write 2 to 0x00000002, then write 3 to 0x00000004, and so on). After writing to these locations, we read the data back and verify that it is what we'd expect.
- **Data Test:** This tests the data bus in FRAM memory by writing data values that have only one bit set (i.e. 0x01, 0x02, 0x04) to consecutive locations in memory. Then we read back to make sure that all data was written properly.

Failure on any of these tests will produce a FAIL result for PT11.

```
>pt11
FRAM test...PASS
```

PT12 - RAM Test

The PT12 command performs the tests described for PT11 above on the RAM.

```
>pt12
RAM test...PASS
```

PT13 - ROM Test

The PT13 command performs a test of the flash ROM by comparing the CRC of the data in ROM with the CRC value stored in FLASH. If the values differ, PT13 will result in a FAIL.

```
>pt13
ROM Test...PASS [ 60e0 ]
```

PT14 - Recorder Test

The PT14 recorder test takes about 10 minutes to complete, as it checks all 32768 pages of each flash chip (x2), at 256 bytes per page to ensure the chips are completely blank. It then performs a pattern test of a random sector in each flash chip, which is fairly quick. The PT14 recorder test will quickly fail with an error message if the recorder has not been erased first.

```
>pt14

Performing Recorder Flash Test...

Blank check MEM0:
65536
Blank check MEM1:
32768
Rec Flash Pattern Test:
Testing 10 addresses in sector #36

Rec Flash Pattern Test:
Testing 10 addresses in sector #33

Recorder Flash Test: PASS
```

PT19 - Ringing Test

The PT19 Ringing test is reserved for TRDI use. It has a binary output that is used by special TRDI test software, and is not meant to be run manually.

Expert Performance and Testing Commands

This section lists the expert Performance and Testing commands. Commands that start with the # sign are considered “expert” commands.

>#p?

Available Commands:

```
#PD 0 ----- Data Stream Select, 0,4,5,6,13
#PE 00000 ----- Ethernet Data Streams Bitmask (PD0,4,5,6,13)
#P? ----- Display P-Command Menu
```

#PD - Data Stream Select

Purpose Selects the type of ensemble output data structure.

Format #PDn



The PD command works with or without the # sign. For example, using PD or #PD are both valid commands.

Range n = 0, 4, 5, 6, 11, 13, and 26 (see description)

Default #PD0



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 29).

Table 29: Data Stream Selections

Format	Description
PD0	PD0 output is a binary output that is somewhat configurable via other commands (such as WD, BJ, #EE), and can send all bottom track, water track, profile, and sensor data being collected by the DVL. For a full description of the PD0 format, see PD0 Output Data Format .
PD4	PD4 Sends CSS-DVL output data structure (without sensor and made-good data). For a full description of the PD4 format, see Pathfinder Binary Data Format (PD4/PD5) .
PD5	PD5 Sends CSS-DVL output data structure (with sensor and made-good data). For a full description of the PD5 format, see Pathfinder Binary Data Format (PD5) .
PD6	PD6 Sends an ASCII data stream containing bottom track and water layer velocity information for all coordinate transformations. For a full description of the PD6 format, see Pathfinder Output Data Format (PD6) .
PD11	PD11 is a text output format. It complies with the NMEA 0183 version 2.30 standard. For a full description of the PD11 format, see Pathfinder NMEA Output (PD11) .
PD13	PD13 outputs similar to PD6, except it adds Pressure and Range-to-bottom for all four beams, and omits System Health Monitor Data line. For a full description of the PD13 format, see Pathfinder Output Data Format (PD13) .
PD26	PD26 Speed Log Format includes the \$VMVBW, \$VMDBT, and \$VMVLW messages. For a full description of the PD26 format, see Pathfinder Speed Log Format (PD26) .

#PE – Ethernet Data Streams Bitmask

Purpose Selects the multiple formats to be enabled simultaneously for Pathfinder systems with the optional Ethernet module.

Format #PEnnnnn



The PE command works only with the # sign.

Range $n = 0, 1$ Ethernet Data Streams Bitmask (PD0,4,5,6,13)

Default #PE 00000



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

Description When the Pathfinder is configured for Ethernet operation, the #PE command enables each output format selected from PD0, PD4, PD5, PD6, and PD13 using the Network Configuration page (see [Using the Network Configuration Page](#)), allowing multiple formats to be enabled simultaneously. For example, setting #PE10001 will select PD0 and PD13 output formats.



If all outputs are enabled, it can affect the ping rate.

Timing Commands

These commands set the timing of various profiling functions.

Available Timing Commands

This section lists the available Timing commands.

>T?

Available Commands:

```
TE 00:00:00.00 ----- Time Between Ensembles
TF --/--/--,--:--:-- ----- Set First Ping Time (yy/mm/dd, hh:mm:ss)
TP 00:00.00 ----- Time Between Pings
TS 15/04/21,10:15:59.14 --- Set System Date and Time
TT 2015/04/21,10:15:59.14 - Set System Date and Time (4-digit year)
T? ----- Display T-Command Menu
```

TE – Time Per Ensemble

Purpose Sets the minimum interval between data collection cycles (data ensembles).

Format TEhh: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 TE00:00:00.00



Set as needed.

Description During the ensemble interval set by TE, the Pathfinder transmits the number of pings set by the WP-command (see [WP – Pings Per Ensemble](#)). If TE = 00:00:00.00, the Pathfinder starts collecting the next ensemble immediately after processing the previous ensemble.

Example TE01:15:30.00 tells the Pathfinder to collect data ensembles every 1 hour, 15 minutes, 30 seconds.



1. The Pathfinder 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 Pathfinder starts data collection.

Format TFyy/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

Description The TF command delays the start of data collection. The Pathfinder can be deployed in the Standby mode and have it automatically start data collection at a preset time. When the command is given to the Pathfinder to start pinging, TF is tested for validity. If valid,

the Pathfinder sets its alarm clock to TF, goes to sleep, and waits until time TF before beginning the data collection process.

Example If the exact time of the first ping needs to be on November 23, 2013 at 1:37:15 pm, enter TF13/11/23, 13:37:15. If the Pathfinder should begin pinging immediately after receiving the CS command (see notes), do not enter a TF command value.



1. Although a TF command may be sent to the Pathfinder, the CS command also must be sent before deploying the Pathfinder.
2. If the entry is not valid, the Pathfinder sends an error message and does not update the wake-up time.
3. Sending a <BREAK> clears the TF time.
4. The delimiters are optional, and may be spaces.

TP – Time Between Pings

Purpose Sets the *minimum* time between pings.

Format TPmm:ss.ff

Range mm = 00 to 59 minutes
ss = 00 to 59 seconds
ff = 00 to 99 hundredths of seconds

Default TP00:00.00



Set as needed.

Description The Pathfinder interleaves individual pings within a group so they are evenly spread throughout the ensemble.

During the ensemble interval set by TE, the Pathfinder transmits the number of pings set by the WP and BP commands (see [WP – Pings Per Ensemble](#) and [BP – Bottom-Track Pings per Ensemble](#)). TP determines the spacing between the pings. If TP = 0, the Pathfinder 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 – Blank after Transmit](#), [WN – Number of Depth Cells](#), [WS – Depth Cell Size](#), and actual water depth).

Example TP00:00.10 sets the time between pings to 0.10 second.



The Pathfinder automatically increases TE if $(WP \times TP) > TE$.

TS – Set Real-Time Clock

Purpose Sets the Pathfinder's internal real-time clock.

Format TSyy/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



Set using *TRDI Toolz*.

Example TS15/06/17, 13:15:00 sets the real-time clock to 1:15:00 pm, June 17, 2015.



1. When the Pathfinder 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 Pathfinder sends an error message and does not update the real-time clock.

TT – Set Real-Time Clock (Y2k Compliant)

Purpose Sets the Pathfinder's internal real-time clock.

Format TTccyy/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



Set using *TRDI Toolz*.

Example TT2015/06/17, 13:15:00 sets the real-time clock to 1:15:00 pm, June 17, 2015.



1. When the Pathfinder receives the carriage return after the TT-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 Pathfinder 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.

Available Water Profiling Commands

This section lists the available Water Profiling commands.

>W?

Available Commands:

```
WA 050 ----- False Target Amplitude Threshold [0-255]
WB 1 ----- Bandwidth 0=Wide, 1=Narrow
WC 064 ----- Correlation Threshold [0-255]
WD 111110000 ----- Data Out {v;c;a;p;s;*;*;*}
WE 2000 ----- Error Velocity Threshold (mm/s)
WF 0088 ----- Blanking Distance [0-9999cm]
WJ 1 ----- BroadBand Rcvr Gain [0=Lo,1=Hi]
WN 030 ----- Number of Bins [1-255]
WP 000 ----- Number of Pings [0-16384]
WS 0200 ----- Bin Size [cm]
WT 0000 ----- Transmit Length (cm)
WV 0383 ----- Ambiguity Velocity [20-700cm/s]
W? ----- Display W-Command Menu
```



All water profile commands can be accessed without a leading '#' character. The descriptions for WA, WC, WE, WJ, and WT commands are described in the [Expert Water Profiling Command Descriptions](#) section.

WB – Bandwidth

Purpose Sets the profiling bandwidth (sampling rate). Smaller bandwidths allow the Pathfinder to profile farther, but the standard deviation is increased by as much as 2.5 times.

Format WBn

Range n = 0 (Not allowed), 1 (Narrow)

Default WB1



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

Description See table below.

Table 30: Bandwidth Control

Bandwidth	Sample rate	Data variance	Profiling range
0 = Wide (25%)	Not allowed	Not allowed	Not allowed
1 = Narrow (6.25%)	Low	High	High

WD – Data Out

Purpose	Selects the data types collected by the Pathfinder.
Format	WD <i>abc def ghi</i>
Range	Firmware switches (see description)
Default	WD 111 110 000



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

Description WD uses firmware switches to tell the Pathfinder the types of data to collect. The Pathfinder always collects header data, fixed and variable leader data, and checksum data. Setting a bit to one tells the Pathfinder to collect that data type. The bits are described as follows:

<i>a</i> = Velocity	<i>d</i> = Percent good	<i>g</i> = Reserved
<i>b</i> = Correlation	<i>e</i> = Status	<i>h</i> = Reserved
<i>c</i> = Echo Intensity	<i>f</i> = Reserved	<i>i</i> = Reserved

Example WD 111 100 000 (default) tells the Pathfinder to collect velocity, correlation magnitude, echo intensity, percent-good and status.



1. Each bit can have a value of one or zero. Setting a bit to one means output data, zero means suppress data.
2. If WP = zero, the Pathfinder does not collect water-profile data.
3. Spaces in the command line are allowed.
4. Status data is not used, as it does not mean anything.

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 <i>nnnn</i>
Range	<i>nnnn</i> = 0 to 9999 cm
Default	WFO088 (600 kHz)



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

Description WF positions the start of the first depth cell at some vertical distance from the transducer head. This allows the Pathfinder 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.



1. The distance to the middle of depth cell #1 is a function of WF, [WS – Depth Cell Size](#), 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 Pathfinder.

WN – Number of Depth Cells

Purpose	Sets the number of depth cells over which the Pathfinder collects data.
Format	WNnnnn
Range	nnn = 001 to 255 depth cells
Default	WNo30



Set as needed.

Description The range of the Pathfinder is set by the number of depth cells (WN) times the size of each depth cell [WS – Depth Cell Size](#).



Be careful when setting up long profiles. System memory limitations will limit the amount of data actually collected. Those bins not processed will be marked invalid when output.

WP – Pings per Ensemble

Purpose	Sets the number of pings to average in each data ensemble.
Format	WPnnnnnn
Range	nnnnn = 0 to 16384 pings
Default	WP00000



Set as needed.

Description WP sets the number of pings to average in each ensemble before sending/recording the data.



1. If WP = zero the Pathfinder does not collect water-profile data.
2. The Pathfinder automatically extends the ensemble interval [TE – Time Per Ensemble](#) if $(WP+BP) \times TP > TE$.

WS – Depth Cell Size

Purpose	Selects the volume of water for one measurement cell.
Format	WSnnnn
Range	WS10 to WS400 (600 kHz)
Default	WS0200 (600 kHz)



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

Description The Pathfinder collects data over a variable number of depth cells. WS sets the size of each cell in vertical centimeters.

WV – Ambiguity Velocity

Purpose	Sets the radial ambiguity velocity for profile and water mass mode (see BK - Water-Mass Layer Mode).
Format	WVnnn
Range	nnn = 020 to 700 cm/s
Default	WV383



It is strongly recommended that the WV command be left at its' default value of 383.

Description	Set WV as low as possible to attain maximum performance, but not too low or ambiguity errors will occur. The WV command (ambiguity velocity setting) sets the maximum velocity that can be measured along the beam. WV is used to improve the single-ping standard deviation. The lower the value of the WV command, the lower the single-ping standard deviation. Set the WV command based on the maximum apparent velocity (Pathfinder motion plus water speed). The following formula is used to determine the setting of the WV command: $WV = (\text{Max. Apparent Vel. cm/s}) * \sin(\text{beam angle}) * 1.2$ Be aware that the firmware will accept larger values for the WV command; however, WV values that exceed the default values will result in collecting data with ambiguity resolving errors or completely erroneous values.
Example	If the maximum expected Pathfinder horizontal velocity (vessel velocity) is 250 cm/s (≈ 5 kt) and the maximum expected horizontal water velocity is 100 cm/s, set WV to $([250+100]*0.5*1.2=)$ 210 cm/s.

Expert Water Profiling Command Descriptions

This section lists the expert Water Profiling commands. Commands that start with the # sign are considered “expert” commands.

>#W?

Available Commands:

```
#WA 050 ----- False Target Amplitude Threshold [0-255]
#WC 064 ----- Correlation Threshold [0-255]
#WE 2000 ----- Error Velocity Threshold (mm/s)
#WJ 1 ----- BroadBand Rcvr Gain [0=Lo,1=Hi]
#WT 0000 ----- Transmit Length (cm)
#WX 0 ----- Set single-beam transmit mode
#W? ----- Display #W-Command Menu
```

#WA – False Target Threshold Maximum

Purpose Sets a false target (fish) filter.

Format #WAnnn



The WA command works with or without the # sign. For example, using WA or #WA are both valid commands.

Range nnn = 0 to 255 counts (255 disables this filter)

Default #WA050



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

Description The Pathfinder 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 Pathfinder 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.

#WC – Low Correlation Threshold

Purpose Sets the minimum threshold of water-track data that must meet the correlation criteria for profile and water mass mode (see [BK - Water-Mass Layer Mode](#)).

Format #WCnnn



The WC command works with or without the # sign. For example, using WC or #WC are both valid commands.

Range nnn = 0 to 255 counts

Default #WC64



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

Description The Pathfinder 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 – Depth Cell Size](#)). The #WC command sets the threshold of the correlation below, which the Pathfinder 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.

#WE – Error Velocity Threshold

Purpose Sets the maximum error velocity for good water-current data.

Format WEnnnn



The WE command works with or without the # sign. For example, using WE or #WE are both valid commands.

Range nnnn = 0 to 5000 mm/s

Default #WE2000



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 Pathfinder'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.

#WJ – Receiver Gain Select

Purpose Allows the Pathfinder to reduce receiver gain by 40 dB for profile and water mass mode (see [BK - Water-Mass Layer Mode](#)).

Format #WJn



The WJ command works with or without the # sign. For example, using WJ or #WJ are both valid commands.

Range n = 0 (low), 1 (high)

Default #WJ1



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

Description #WJ0 tells the Pathfinder 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.

#WT – Transmit Length

Purpose Selects a transmit length different from the depth cell length (cell sampling interval) as set by the WS command (see [WS – Depth Cell Size](#)).

Format #WTnnnn



The WT command works with or without the # sign. For example, using WT or #WT are both valid commands.

Range nnnn = 0 to 3200 cm

Default #WT0000



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).

#WX – Set single-beam transmit mode

Purpose Sets the single-beam transmit mode.

Format #WX n



The WX command works with or without the # sign. For example, using WX or #WX are both valid commands.

Range n = 0 to 4

Default #WX 0



Use this command only for debugging and testing. The default setting for this command is recommended for most applications.

Description #WX 0 (default) disables the feature and transmits on all beams normally. #WX 1 to 4 selects one beam that will transmit, while data will be received on all four beams.

NOTES

Chapter 8

OUTPUT DATA FORMATS



In this chapter, you will learn:

- Choosing a Data Format
- PDO Output Data Format
- Special Output Data Formats PD4, PD5, PD6, and PD13
- External Sensor Suite Interface Descriptions

Choosing a Data Format

The Pathfinder can output data in several user selectable formats using the PD command (see [PD - Data Stream Select](#)). Depending on the output format selected, data will be either binary or ASCII text.

Binary Output Data Format

Use the binary format (CFxx1xx) when recording/processing Pathfinder data on an external device. The binary format uses less storage space and has a faster transmission time than the Hex ASCII format. A dumb terminal is of little use in binary format because the terminal interprets some of the data as control characters.



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

Hexadecimal-ASCII Output Data

Use the hexadecimal-ASCII (Hex ASCII) format (CFxx2xx) when viewing raw Pathfinder data on a computer/dumb terminal. This format uses the standard ASCII codes for 0 through F to represent numeric values as hexadecimal digits. Other standard ASCII characters (text) and control commands (carriage return, line feed, end of file, etc.) are interpreted normally. In the Hex ASCII mode, the Pathfinder sends data in one line of ASCII characters. There are no carriage returns and/or line feed sequences (CR/LF) sent from the Pathfinder. The CRT provides a CR/LF after 60 characters.



Hex ASCII PD0 data is not supported by TRDI's software.



When operating in HEX mode, all console text appears in HEX - including the prompt ">" (HEX "3E") and any additional commands that are typed.

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 using the CF command (see [CF - Flow Control](#)). HEX-ASCII is an ASCII representation of the binary data. Binary output formats include PD0, PD4, and PD5. Text output formats include PD6.

Deciding on which format to use depends on the needs of the deployment. The following describes the basics of the formats available.

- **PD0** – PD0 is Teledyne RD Instrument'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. PD0 has distance made good in the output if the Bottom Track High Resolution Velocity Output Format is selected. This format is selected via the #BJ command (see [BJ – Data Type Output Control](#)).



The Bottom-Track High Resolution Velocity (5803h) and Navigation Parameters Data (2013h) blocks provide aid in the velocity measurement resolution and quality information for use in an Extended Kalman Filter (EKF) Inertial Navigation System (INS) solution.

- **PD4** – PD4 is a binary output format of bottom track speed over the bottom, speed through the water, and range to bottom information.
- **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. If PD6 is selected, there is no data written to the recorder.
- **PD11** is a text output format. It complies with the NMEA 0183 version 2.30 standard.
- **PD13** - PD13 outputs similar to PD6, except it adds Pressure and Range-to-bottom for all four beams and omits the System Health Monitor Data line.
- **PD26** - The PD26 format includes the \$VMVBW, \$VMDBT, and \$VMVLW NMEA Speed Log Formats.

The following table is a summary of the type of data outputted by PD0 through PD6 data output formats. 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.

Table 31: Summary of Output Data Formats

	PD0	PD4	PD5	PD6	PD11	PD13	PD26
System Info	☑	☑	☑				
Temperature	☑	☑	☑	☑		☑	
Depth	☑		☑	☑	☑	☑	☑
Pressure						☑	
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	☑ see note		☑		☑		☑
Sea-Bird							
Binary	☑	☑	☑				
ASCII				☑		☑	
NMEA					☑		☑
Serial Output	☑	☑	☑	☑	☑	☑	☑
Recorded on PC Card	PD0	PD4	PD5	None	None	None	None

*SOG = Speed Over Ground

*STW = Speed Through Water



The PD0 [Bottom Track output data format](#) assumes that the instrument is stationary and the bottom is moving. See the [EX – Coordinate Transformation](#) command and [Beam Coordinate Systems](#) for details.

- 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 negative.



The [PD0 Bottom Track High Resolution Velocity Output](#) (velocity in 0.01mm/s) and PD3 through PD26 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 positive.



PD0 has distance made good in the output if the Bottom Track High Resolution Velocity Output Format is selected. This format is selected via the #BJ command (see [BJ – Data Type Output Control](#)).

PD0 Output Data Format

The following description is for the standard PD0 Pathfinder output data format. Figure 30 through Figure 44 shows the ASCII and binary data formats for the Pathfinder PD0 mode. Table 32 through Table 47 defines each field in the output data structure.

The binary output data formats are composed of at least one data type, i.e. a group of bytes all related by their dynamic or field. For instance in the PD0 data format, variables that do not change during the deployment are stored in the [Fixed Leader](#) data type of leader ID 0000h, whereas the dynamic variables, except velocities, which dynamically change during the deployment are stored under the [Variable Leader](#) data type of leader ID 0080h. This distinction is based on the dynamic; other distinctions are present such as velocity types such as data type of leader ID 0100h which groups all the [Water Profile Velocity](#) data and leader ID 0600h stores all [Bottom Track Velocity](#) data. The Pathfinder sends all the data for a given type for all depth cells and all beams before the next data type begins.

The PD0 Header ID is 7F7Fh, which makes it easy to detect. In the PD0 Header are the number of bytes in the ensemble, the number of data types and the offset respective to each data type location in the binary ensemble.

PD0 is the only binary output data format which provides a [Header](#) that describes the data included in the ensemble since some data types presence in the PD0 output are dependent on commands parameters. For example, if the number of Bottom Track pings is 0 (BPO), then there will be no Bottom track data type in the ensemble. The table below shows which data types are always output against command dependable data types:

Output	ID (MSB LSB)	Description
ALWAYS OUTPUT	7F 7Fh	HEADER (6 BYTES + [2 x No. OF DATA TYPES])
	00 00h	FIXED LEADER DATA (58 BYTES)
	00 80h	VARIABLE LEADER DATA (77 BYTES)
WATER PROFILING DATA WD command WP command	01 00h	VELOCITY (2 BYTES + 8 BYTES PER DEPTH CELL)
	02 00h	CORRELATION MAGNITUDE (2 BYTES + 4 BYTES PER DEPTH CELL)
	03 00h	ECHO INTENSITY (2 BYTES + 4 BYTES PER DEPTH CELL)
	04 00h	PERCENT GOOD (2 BYTES + 4 BYTES PER DEPTH CELL)
BP command #BJ command	06 00h	BOTTOM TRACK DATA (81 BYTES)
	58 00h	BOTTOM TRACK COMMAND OUTPUT (43 BYTES)
	58 03h	BOTTOM TRACK HIGH RESOLUTION VELOCITY (70 BYTES)
	58 04h	BOTTOM TRACK RANGE (41 BYTES)
	20 13h	NAVIGATION PARAMETERS DATA (85 BYTES)
#EE command	30 00h	ENVIRONMENT COMMAND PARAMETERS OUTPUT (47 BYTES)
	30 01h	SENSOR SOURCE FOR DOPPLER PROCESSING (62 BYTES)
ALWAYS OUTPUT		CHECKSUM (2 BYTES)

Figure 29. PD0 Standard Output Data Buffer Format

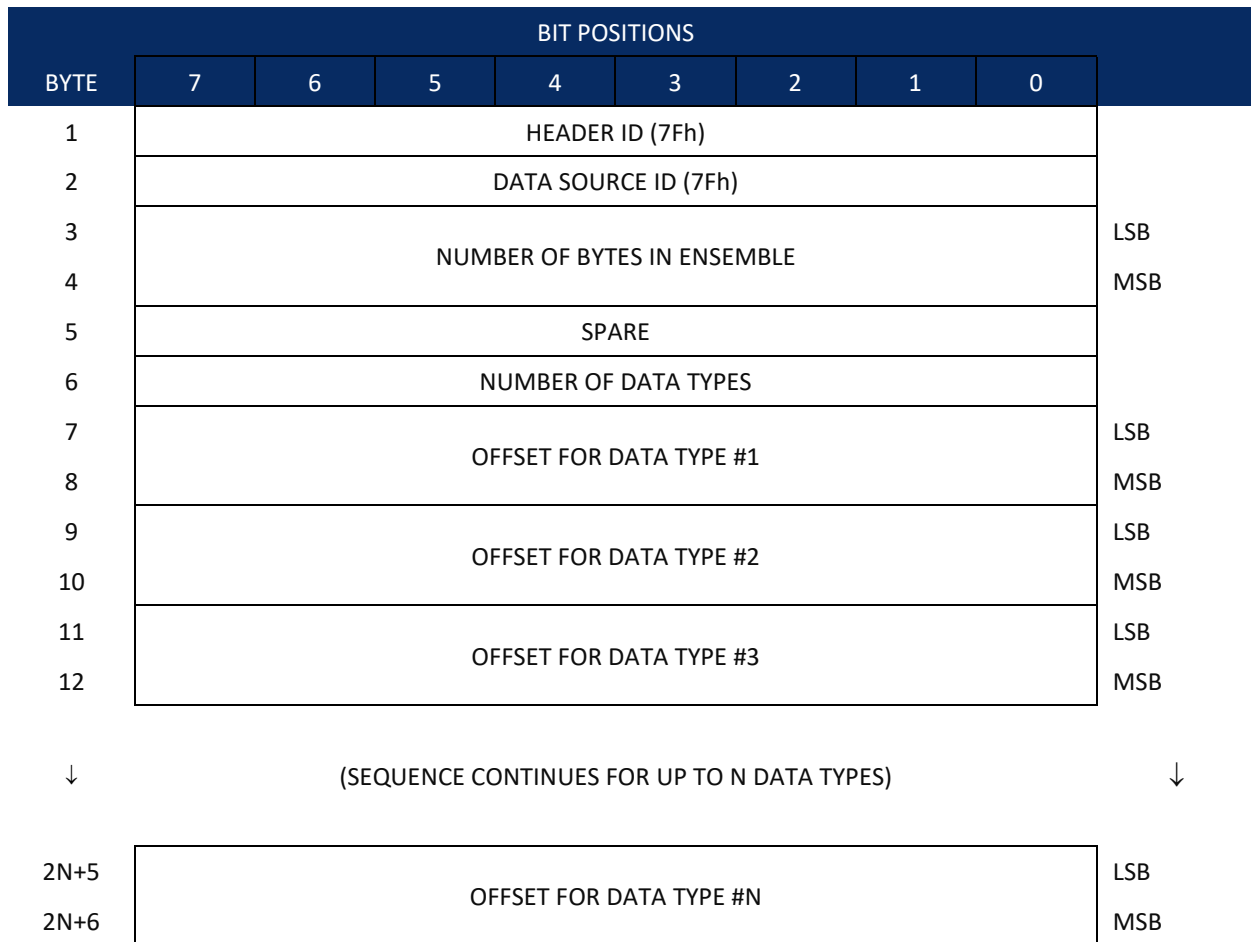


The Pathfinder always sends the Least Significant Byte (LSB) first.

Some data outputs are in bytes per depth cell. For example, if the WN-command = 30 (default), WD command = WD 111 110 000 (default), WP command > 0, BP command > 0, the required data buffer storage space is 951 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])
58	BYTES OF FIXED LEADER DATA (FIXED)
77	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)
122	BYTES OF PROFILE STATUS DATA (2 + 4 x 30)
81	BYTES OF BOTTOM TRACK DATA (FIXED)
2	BYTES OF CHECKSUM DATA (FIXED)
968	BYTES OF DATA PER ENSEMBLE

Header Data Format



See Table 32 for a description of the fields.

Figure 30. Binary Header Data Format

Header information is the first item sent by the Pathfinder to the output buffer. The Pathfinder always sends the Least Significant Byte (LSB) first.

Table 32: 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 Pathfinder).
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 44).
9,10	5	Spare	3-byte checksum offset, which would allow the output of a very large data type in the PDO message, although no data type can start beyond the reach of a 16-bit offset word in the header.
11,12	6	No. DT / Number of Data Types	This field contains the number of data types selected for collection. By default, fixed/variable leader, velocity, correlation magnitude, echo intensity, and percent good are selected for collection. This field will therefore have a value of six (4 data types + 2 for the Fixed/Variable Leader data).
13-16	7,8	Address Offset for Data Type #1 / Offset for Data Type #1	This field contains the internal memory address offset where the Pathfinder will store information for data type #1 (with this firmware, always the Fixed Leader). Adding "1" to this offset number gives the absolute Binary Byte number in the ensemble where Data Type #1 begins (the first byte of the ensemble is Binary Byte #1).
17-20	9,10	Address Offset for Data Type #2 / Offset for Data Type #2	This field contains the internal memory address offset where the Pathfinder 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 Pathfinder 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

BIT POSITIONS									
BYTE	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								
11	PINGS PER ENSEMBLE								LSB
12									MSB
13	DEPTH CELL LENGTH								LSB
14									MSB
15	BLANK AFTER TRANSMIT								LSB
16									MSB
17	PROFILING MODE								
18	LOW CORR THRESH								
19	NO. CODE REPS								
20									
21	ERROR VELOCITY MAXIMUM								LSB
22									MSB
23	TPP MINUTES								
24	TPP SECONDS								
25	TPP HUNDREDTHS								
26	COORDINATE TRANSFORM								
27	HEADING ALIGNMENT								LSB
28									MSB

BYTE	BIT POSITIONS								
	7	6	5	4	3	2	1	0	
29	HEADING BIAS								LSB
30									MSB
31	SENSOR SOURCE								
32	SENSORS AVAILABLE								
33	BIN 1 DISTANCE								
34									
35	XMIT PULSE LENGTH								LSB
36									MSB
37	SPARE								LSB
38									MSB
39	FALSE TARGET THRESH								
40	SPARE								
41	TRANSMIT LAG DISTANCE								LSB
42									MSB
43	SPARE								LSB
↓									↓
50									MSB
51	SYSTEM BANDWIDTH								LSB
52									MSB
53	SPARE								
54	SPARE								
55	System Serial Number								LSB
↓									↓
58									MSB

See Table 33 for a description of the fields

Figure 31. Fixed Leader Data Format

Fixed Leader data refers to the non-dynamic Pathfinder data that only changes when certain commands are changed. Fixed Leader data also contains hardware information. The Pathfinder always sends Fixed Leader data as output data (LSBs first).

Table 33: 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 Pathfinder hardware configuration. Convert this field (2 bytes, LSB first) to binary and interpret as follows. LSB <table><tr><td>BITS</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td><td></td></tr><tr><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>0</td><td>0</td><td>0</td><td>75-kHz SYSTEM</td></tr><tr><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>0</td><td>0</td><td>1</td><td>150-kHz SYSTEM</td></tr><tr><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>0</td><td>1</td><td>0</td><td>300-kHz SYSTEM</td></tr><tr><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>0</td><td>1</td><td>1</td><td>600-kHz SYSTEM</td></tr><tr><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>1</td><td>0</td><td>0</td><td>1200-kHz SYSTEM</td></tr><tr><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>1</td><td>0</td><td>1</td><td>2400-kHz SYSTEM</td></tr><tr><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>0</td><td>-</td><td>-</td><td>-</td><td>CONCAVE BEAM PAT.</td></tr><tr><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>1</td><td>-</td><td>-</td><td>-</td><td>CONVEX BEAM PAT.</td></tr><tr><td></td><td>-</td><td>-</td><td>0</td><td>0</td><td>-</td><td>-</td><td>-</td><td>-</td><td>SENSOR CONFIG #1</td></tr><tr><td></td><td>-</td><td>-</td><td>0</td><td>1</td><td>-</td><td>-</td><td>-</td><td>-</td><td>SENSOR CONFIG #2</td></tr><tr><td></td><td>-</td><td>-</td><td>1</td><td>0</td><td>-</td><td>-</td><td>-</td><td>-</td><td>SENSOR CONFIG #3</td></tr><tr><td></td><td>-</td><td>0</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>XDCR HD NOT ATT.</td></tr><tr><td></td><td>-</td><td>1</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>XDCR HD ATTACHED</td></tr><tr><td></td><td>0</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>DOWN FACING BEAM</td></tr><tr><td></td><td>1</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>UP-FACING BEAM</td></tr></table> MSB <table><tr><td>BITS</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td><td></td></tr><tr><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>0</td><td>0</td><td>15E BEAM ANGLE</td></tr><tr><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>0</td><td>1</td><td>20E BEAM ANGLE</td></tr><tr><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>1</td><td>0</td><td>30E BEAM ANGLE</td></tr><tr><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>1</td><td>1</td><td>OTHER BEAM ANGLE</td></tr><tr><td></td><td>0</td><td>1</td><td>0</td><td>0</td><td>-</td><td>-</td><td>-</td><td>-</td><td>4-BEAM JANUS CONFIG</td></tr><tr><td></td><td>0</td><td>1</td><td>0</td><td>1</td><td>-</td><td>-</td><td>-</td><td>-</td><td>5-BM JANUS CFG DEMOD)</td></tr><tr><td></td><td>1</td><td>1</td><td>1</td><td>1</td><td>-</td><td>-</td><td>-</td><td>-</td><td>5-BM JANUS CFG. (2 DEMD)</td></tr></table> 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).	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	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 CFG DEMOD)		1	1	1	1	-	-	-	-	5-BM JANUS CFG. (2 DEMD)
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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.																																																																																																																																																																																																																																																
17,18	9	#Bm / Number of Beams	Contains the number of beams used to calculate velocity data (not physical beams). The Pathfinder 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 Pathfinder does not make this validity check. Table 38 (Percent-Good Data Format) has more information.																																																																																																																																																																																																																																																

Table 33: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description
19,20	10	WN / Number of Cells	Contains the number of depth cells over which the Pathfinder collects data (WN – Number of Depth Cells). Scaling: LSD = 1 depth cell; Range = 1 to 255 depth cells
21-24	11,12	WP / Pings Per Ensemble	Contains the number of pings averaged together during a data ensemble (WP – Pings Per Ensemble). If WP = 0, the Pathfinder does not collect the WD water-profile data. Note: The Pathfinder 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 = 1 to 16,384 pings
25-28	13,14	WS / Depth Cell Length	Contains the length of one depth cell (WS – Depth Cell Size). Scaling: LSD = 1 centimeter; Range = 1 to 1600 cm (52.5 feet)
29-32	15,16	WF / Blank after Transmit	Contains the blanking distance used by the Pathfinder to allow the transmit circuits time to recover before the receive cycle begins (WF – Blank after Transmit). 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 - Low Correlation Threshold). 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	% Good 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 Pathfinder flags all four beams of the affected bin as bad (see WE - Error Velocity Threshold). Scaling: LSD = 1 mm/s; Range = 0 to 5000 mm/s
45,46	23	Minutes	These fields, set by the TP-command, contain the amount of time between ping groups in the ensemble. NOTE: The Pathfinder automatically extends the ensemble interval (set by TE) if (WP x TP > TE). See TP – Time Between Pings .
47,48	24	Seconds	
49,50	25	Hundredths	

Table 33: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description																		
51,52	26	EX / Coord Transform	Contains the coordinate transformation processing parameters (EX – Coordinate Transformation). These firmware switches indicate how the Pathfinder collected data. xxx00xxx = NO TRANSFORMATION (BEAM COORDINATES) xxx01xxx = INSTRUMENT COORDINATES xxx10xxx = SHIP COORDINATES xxx11xxx = EARTH COORDINATES xxxxx1xx = TILTS (PITCH AND ROLL) USED IN SHIP OR EARTH TRANSFORMATION xxxxxx1x = 3-BEAM SOLUTION USED IF ONE BEAM IS BELOW THE CORRELATION THRESHOLD SET BY THE WC-COMMAND xxxxxxx1 = BIN MAPPING USED																		
53-56	27,28	EA / Heading Alignment	Contains a correction factor for physical heading misalignment (EA - Heading Alignment). Scaling: LSD = 0.01 degree; Range = -179.99 to 180.00 degrees																		
57-60	29,30	#EV / Heading Bias	Contains a correction factor for electrical/magnetic heading bias (EV - Heading Bias). Scaling: LSD = 0.01 degree; Range = -179.99 to 180.00 degrees																		
61,62	31	EZ / Sensor Source	Contains the selected source of environmental sensor data (EZ - Sensor Source). These firmware switches indicate the following. <table><thead><tr><th>FIELD</th><th>DESCRIPTION</th></tr></thead><tbody><tr><td>1xxxxxxx</td><td>CALCULATES EC (SPEED OF SOUND) FROM ED, ES, AND ET</td></tr><tr><td>x1xxxxxx</td><td>USES ED FROM DEPTH SENSOR</td></tr><tr><td>xx1xxxxx</td><td>USES EH FROM TRANSDUCER HEADING SENSOR</td></tr><tr><td>xxx1xxxx</td><td>USES EP FROM TRANSDUCER PITCH SENSOR</td></tr><tr><td>xxxx1xxx</td><td>USES ER FROM TRANSDUCER ROLL SENSOR</td></tr><tr><td>xxxxx1xx</td><td>USES ES (SALINITY) FROM CONDUCTIVITY SENSOR</td></tr><tr><td>xxxxxx1x</td><td>USES ET FROM TRANSDUCER TEMPERATURE SENSOR</td></tr><tr><td>xxxxxxx1</td><td>USES EU FROM TRANSDUCER TEMPERATURE SENSOR</td></tr></tbody></table> NOTE: If the field = 0, or if the sensor is not available, the Pathfinder uses the manual command setting. If the field = 1, the Pathfinder uses the reading from the internal sensor or an external synchro sensor (only applicable to heading, roll, and pitch). Although a “2” in the EZ-command string can be entered, the Pathfinder only displays a 0 (manual) or 1 (int/ext sensor).	FIELD	DESCRIPTION	1xxxxxxx	CALCULATES EC (SPEED OF SOUND) FROM ED, ES, AND ET	x1xxxxxx	USES ED FROM DEPTH SENSOR	xx1xxxxx	USES EH FROM TRANSDUCER HEADING SENSOR	xxx1xxxx	USES EP FROM TRANSDUCER PITCH SENSOR	xxxx1xxx	USES ER FROM TRANSDUCER ROLL SENSOR	xxxxx1xx	USES ES (SALINITY) FROM CONDUCTIVITY SENSOR	xxxxxx1x	USES ET FROM TRANSDUCER TEMPERATURE SENSOR	xxxxxxx1	USES EU FROM TRANSDUCER TEMPERATURE SENSOR
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xxxxxx1x	USES ET FROM TRANSDUCER TEMPERATURE SENSOR																				
xxxxxxx1	USES EU FROM TRANSDUCER TEMPERATURE SENSOR																				
63,64	32	Sensor Avail	This field reflects which sensors are available. The bit pattern is the same as listed for the EZ-command (above).																		
65-68	33,34	dis1 / Bin 1 distance	This field contains the distance to the middle of the first depth cell (bin). This distance is a function of depth cell length (WS), the profiling mode (WM), the blank after transmit distance (WF), and speed of sound. Scaling: LSD = 1 centimeter; Range = 0 to 65535 cm (2150 feet)																		

Table 33: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description
69-72	35,36	WT Xmit pulse length	This field, set by the WT-command (WT - Transmit Length), contains the length of the transmit pulse. When the Pathfinder receives a <BREAK> signal, it sets the transmit pulse length as close as possible to the depth cell length (WS – Depth Cell Size). This means the Pathfinder uses a WT <u>command</u> of zero. However, the WT <u>field</u> 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	Spare	Spare
77,78	39	#WA / False Target Threshold	Contains the threshold value used to reject data received from a false target, usually fish (WA - False Target Threshold Maximum). 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	Spare	Spare
101-105	51-52	System Bandwidth	Contains the system bandwidth setting. Range = 0 to 1
106-107	53	Spare	Spare
108-109	54	Spare	Spare
110-119	55-58	System Serial Number	System Serial Number

Variable Leader Data Format

BIT POSITIONS										
BYTE	7	6	5	4	3	2	1	0		
1	VARIABLE LEADER ID								LSB 80h	
2									MSB 00h	
3	ENSEMBLE NUMBER								LSB	
4									MSB	
5	RTC YEAR									
6										RTC MONTH
7										RTC DAY
8										RTC HOUR
9										RTC MINUTE
10										RTC SECOND
11	RTC HUNDREDTHS									
12	ENSEMBLE # MSB									
13	BIT RESULT								LSB	
14									MSB	
15	SPEED OF SOUND								LSB	
16									MSB	
17	DEPTH OF TRANSDUCER								LSB	
18									MSB	
19	HEADING								LSB	
20									MSB	
21	PITCH (TILT 1)								LSB	
22									MSB	
23	ROLL (TILT 2)								LSB	
24									MSB	
25	SALINITY								LSB	
26									MSB	
27	TEMPERATURE								LSB	
28									MSB	
29	MPT MINUTES									
30										MPT SECONDS
31										MPT HUNDREDTHS

BIT POSITIONS								
BYTE	7	6	5	4	3	2	1	0
32	HDG STD DEV							
33	PITCH STD DEV							
34	ROLL STD DEV							
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)							LSB
44								
45								
46	SPARE							MSB
47								
48	PRESSURE							LSB
49								
50								
51	PRESSURE SENSOR VARIANCE							MSB
52								
53								LSB
54	PRESSURE SENSOR VARIANCE							
55								
56								MSB
57	SPARE							
↓								↓
↓								↓
66								

BIT POSITIONS								
BYTE	7	6	5	4	3	2	1	0
67	HEALTH STATUS							
68	LEAK A COUNT							LSB
69								MSB
70	LEAK B COUNT							LSB
71								MSB
72	TX VOLTAGE							LSB
73								MSB
74	TX CURRENT							LSB
75								MSB
76	TRANSDUCER IMPEDANCE							LSB
77								MSB

Figure 32. Variable Leader Data Format

Variable Leader data refers to the dynamic Pathfinder data (from clocks/sensors) that change with each ping. The Pathfinder always sends Variable Leader data as output data (LSBs first).

Table 34: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	VID / Variable Leader ID	Stores the Variable Leader identification word (MSB=00h LSB=80h).
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: <pre> 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. </pre>
9,10	5	RTC Year	These fields contain the time from the Pathfinder’s real-time clock (RTC) that the current data ensemble began. The TS-command (TS – Set Real-Time Clock) initially sets the clock. The Pathfinder <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.

Table 34: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
25-28	13,14	BIT / BIT Result	This field contains the results of the Pathfinder's Built-in Test function. A zero code indicates a successful BIT result. See BIT Decoding Method for non-zero values. <pre> BIT bytel3 Error Code Description 0x01 Transmitter Shutdown 0x02 Transmitter Overcurrent 0x03 Transmitter Undercurrent 0x04 Transmitter Undervoltage 0x10 FIFO interrupt missed 0x11 FIFO ISR re-entry 0x21 Sensor start failure 0x22 temperature sensor failure 0x23 pressure sensor failure 0x27 Bad Comms with sensor 0x28 Bad Comms with sensor 0x29 Sensor Cal Data checksum failure 0x2A Sensor Stream Data Fault 0x30 Stuck UART 0x31 QUART Transmit timeout 0x32 QUART IRQ Stuck 0x33 QUART Buffer stuck 0x34 QUART IRQ Active 0x35 QUART cannot clear interrupt 0x50 RTC low battery 0x51 RTC time not set 0x60 Lost Nonvolatile pointers 0x61 Erase operation failed 0x62 Error writing from flash to buffer 1 0x63 Error writing from buffer 1 to flash 0x64 Timed out checking if page is erased 0x65 Bad return when checking page 0x66 Loop recorder Slate Full 0x70 Unable to write to FRAM 0x80 HEM data corrupt or not initialized. 0x81 HEM data corrupt or not initialized. 0x82 Failed to update HEM data. 0x83 Failed to update HEM data. 0x84 Failed to read HEM time data. 0x85 Failed to read HEM pressure data. 0x86 Failed to read HEM SPI state. 0x87 Operating time over max. 0x88 Pressure reading over sensor limit. 0x89 Leak detected in sensor A. 0x8A Leak detected in sensor B. 0xFF Power failure BIT Number of Errors byte 14 Number of BIT errors </pre>
29-32	15,16	EC / Speed of Sound	Contains either manual or calculated speed of sound information (EC - Speed of Sound). Scaling: LSD = 1 meter per second; Range = 1400 to 1600 m/s

Table 34: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
33-36	17,18	ED / Depth of Transducer	Contains the depth of the transducer below the water surface (ED - Depth of Transducer). This value may be a manual setting or a reading from a depth sensor. Scaling: LSD = 1 decimeter; Range = 1 to 9999 decimeters
37-40	19,20	EH / Heading	Contains the Pathfinder heading angle. This value may be a manual setting (EH - Heading) or a reading from a heading sensor. The variation angle from the EV command is added to heading before output. The coordinate frame this data is referenced to is specified by the EH command. Scaling: LSD = 0.01 degree; Range = 000.00 to 359.99 degrees
41-44	21,22	EP / Pitch (Tilt 1)	Contains the Pathfinder pitch angle. This value may be a manual setting (EP - Pitch and Roll Angles) or a reading from a tilt sensor. Positive values mean that Beam #3 is spatially higher than Beam #4. The coordinate frame this data is referenced to is specified by the EP command. Scaling: LSD = 0.01 degree; Range = -20.00 to +20.00 degrees
45-48	23,24	ER / Roll (Tilt 2)	Contains the Pathfinder roll angle. This value may be a manual setting (ER - Roll Angle) or a reading from a tilt sensor. For an up-facing Pathfinder system, positive values mean that Beam #2 is above the earth's horizontal while than Beam #1 is below the earth's horizontal. For a down-facing Pathfinder system, positive values mean that Beam #1 is above the earth's horizontal and then Beam #2 is below the earth's horizontal. The coordinate frame this data is referenced to is specified by the EP command. Scaling: LSD = 0.01 degree; Range = -20.00 to +20.00 degrees
49-52	25,26	ES / Salinity	Contains the salinity value of the water at the transducer head (ES - Salinity). This value may be a manual setting or a reading from a conductivity sensor. Scaling: LSD = 1 part per thousand; Range = 0 to 40
53-56	27,28	ET / Temperature	Contains the temperature of the water at the transducer head. This value may be a manual setting (ET - Temperature) or a reading from a temperature sensor. Scaling: LSD = 0.01 degree; Range = -5.00 to +40.00 degrees
57,58	29	MPT minutes	This field contains the <u>M</u> inimum Pre- <u>P</u> ing Wait <u>T</u> ime between ping groups in the ensemble.
59,60	30	MPT seconds	
61,62	31	MPT hundredths	
63,64	32	H/Hdg Std Dev	These fields contain the standard deviation (accuracy) of the heading and tilt angles from the gyrocompass/pendulums. Scaling (Heading): LSD = 1°; Range = 0 to 180° Scaling (Tilts): LSD = 0.1°; Range = 0.0 to 20.0°
65,66	33	P/Pitch Std Dev	
67,68	34	R/Roll Std Dev	

Table 34: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description																																																																																
69-70	35	ADC Channel 0	These fields contain the outputs of the Analog-to-Digital Converter (ADC). The ADC channels in the Pathfinder are defined as follows: <table><thead><tr><th>CHANNEL</th><th>DESCRIPTION</th></tr></thead><tbody><tr><td>0</td><td>Not Used</td></tr><tr><td>1</td><td>Rounded voltage as measured during pinging</td></tr><tr><td>2</td><td>Not Used</td></tr><tr><td>3</td><td>Not Used</td></tr><tr><td>4</td><td>Not Used</td></tr><tr><td>5</td><td>Not Used</td></tr><tr><td>6</td><td>Not Used</td></tr><tr><td>7</td><td>Not Used</td></tr></tbody></table> Note that the ADC values may be “noisy” from sample-to-sample, but are useful for detecting long-term trends.	CHANNEL	DESCRIPTION	0	Not Used	1	Rounded voltage as measured during pinging	2	Not Used	3	Not Used	4	Not Used	5	Not Used	6	Not Used	7	Not Used																																																														
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71-72	36	ADC Channel 1																																																																																	
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79-80	40	ADC Channel 5																																																																																	
81-82	41	ADC Channel 6																																																																																	
83-84	42	ADC Channel 7																																																																																	
85-86	43	Error Status Word	Reserved for TRDI use.																																																																																
87-88	44		Reserved for TRDI use.																																																																																
89-90	45		Reserved for TRDI use.																																																																																
91-92	46		Reserved for TRDI use.																																																																																
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. Scaling: LSD=1 deca-pascal; Range=0 to 4,294,967,295 deca-pascals																																																																																
105-112	53-56	Pressure variance	Contains the variance (deviation about the mean) of the pressure sensor data. Output is in deca-pascals. Scaling: LSD=1 deca-pascal; Range=0 to 4,294,967,295 deca-pascals																																																																																
113-114	57-66	Spare	Spare																																																																																
133-134	67	Health Status	Contains the leak sensor flags and flags to indicate whether the transmit voltage, transmit current, and transducer impedance have been updated. These update flags are set when the measurement is made, and cleared after each ensemble output. <table><thead><tr><th>BITS</th><th>07</th><th>06</th><th>05</th><th>04</th><th>03</th><th>02</th><th>01</th><th>00</th><th></th></tr></thead><tbody><tr><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>1</td><td>Leak sensor A leak detected</td></tr><tr><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>1</td><td>*</td><td>Leak sensor A open circuit</td></tr><tr><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>1</td><td>*</td><td>*</td><td>Leak sensor B leak detected</td></tr><tr><td>*</td><td>*</td><td>*</td><td>*</td><td>1</td><td>*</td><td>*</td><td>*</td><td>*</td><td>Leak sensor B open circuit</td></tr><tr><td>*</td><td>*</td><td>*</td><td>1</td><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>Tx voltage updated</td></tr><tr><td>*</td><td>*</td><td>1</td><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>Tx current updated</td></tr><tr><td>*</td><td>1</td><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>Transducer impedance updated</td></tr></tbody></table>	BITS	07	06	05	04	03	02	01	00		*	*	*	*	*	*	*	*	1	Leak sensor A leak detected	*	*	*	*	*	*	*	1	*	Leak sensor A open circuit	*	*	*	*	*	*	1	*	*	Leak sensor B leak detected	*	*	*	*	1	*	*	*	*	Leak sensor B open circuit	*	*	*	1	*	*	*	*	*	Tx voltage updated	*	*	1	*	*	*	*	*	*	Tx current updated	*	1	*	*	*	*	*	*	*	Transducer impedance updated
BITS	07	06	05	04	03	02	01	00																																																																											
*	*	*	*	*	*	*	*	1	Leak sensor A leak detected																																																																										
*	*	*	*	*	*	*	1	*	Leak sensor A open circuit																																																																										
*	*	*	*	*	*	1	*	*	Leak sensor B leak detected																																																																										
*	*	*	*	1	*	*	*	*	Leak sensor B open circuit																																																																										
*	*	*	1	*	*	*	*	*	Tx voltage updated																																																																										
*	*	1	*	*	*	*	*	*	Tx current updated																																																																										
*	1	*	*	*	*	*	*	*	Transducer impedance updated																																																																										
135-138	68-69	Leak A Count	Raw A/D reading, in counts, for leak sensor A. See PC5/50 command for more details on how to decode the raw A/D counts into Leak Status.																																																																																

Table 34: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
139-142	70-71	Leak B Count	Raw A/D reading, in counts, for leak sensor B. See PC5/50 command for more details on how to decode the raw A/D counts into Leak Status.
143-146	72-73	Tx Voltage	Voltage delivered to transducer during transmit. See Transducer Voltage, Current, and Impedance for more information. Scaling: LSD = 0.001 volt (Value set to 0xFFFF if a valid reading is not available.)
147-150	74-75	Tx Current	Current delivered to transducer during transmit. See Transducer Voltage, Current, and Impedance for more information. Scaling: LSD = 0.001 ampere (Value set to 0xFFFF if a valid reading is not available.)
151-154	76-77	Transducer Impedance	Measured impedance of transducer, calculated by dividing voltage by current. See Transducer Voltage, Current, and Impedance for more information. Scaling: LSD = 0.001 ohm (Value set to 0xFFFF if a valid reading is not available or for any reading greater than 65.535 ohms.)



If there is more than one BIT error, then it will take several ensembles to output all the BIT errors. For example, if there are 3 BIT errors detected, then the output will be Bytes13, 14 = 03,xx on ensemble n, Bytes13, 14 = 03,yy on ensemble n+1, and Bytes13, 14 = 03,zz on ensemble n+2, where xx, yy, and zz are the three different error messages detected.

BIT Decoding Method

In order to verify if the system has a BIT set for an ensemble, run the file through *BBCheck.exe* or decode it from the PD0 binary output using *BBConv.exe*.



BBCheck and *BBConv* are included with RDI Tools.

In any case, one will obtain a decimal value greater than zero if a BIT was set during the ensemble.

To decode it, simply convert the decimal value to Hexadecimal and take the first number to the far left as being the number of BIT failure occurrences during the ensemble and the 2 other numbers on the far right to be the BIT code.

For example:

- BIT obtained from *BBCheck* or *BBConv.exe* is '290'.
- Converted to hexadecimal (one can use the Windows calculator for this) gives: '122'.
- Where '1' is the number of occurrences for that BIT and '22' is the BIT failure code which means "Temperature Sensor failure" (see binary bytes 13 and 14).

Transducer Voltage, Current, and Impedance

The Transmit Voltage, Transmit Current, and Transducer Impedance values output in the PDO Variable Leader are obtained from the Transducer Health Monitor measurement, which is part of the [HEM features](#). The measurement is made at the following times:

- During the transmit pulse of a BM8 ping, if the expected altitude ≥ 20 m
- During the transmit pulse of a BM9 ping, if the expected altitude ≥ 20 m



The transmit signal needs to be at least a certain length in order to make a valid measurement.

The measurement is not made during any profile ping or water mass layer ping. Therefore, if bottom pings are not enabled (or not working), then the output of these parameters will be 0xFFFF (i.e. hex FFFF) to mark them as invalid (Note that hex FFFF is equal to decimal 65535 if interpreted as an unsigned number, or -1 if interpreted as a signed number).

If bottom pings are enabled, but the altitude never attains 20 m or above, then the outputs for these parameters will remain at their initial values of 0xFFFF.

If a bottom track ping ever sees an altitude ≥ 20 m then these parameters will be measured and output. If the altitude then goes below 20 m, the output of these parameters will remain at their last measured value; i.e. you need a bottom track ping with altitude ≥ 20 m to update these values.

Velocity Data Format

BIT POSITIONS									
BYTE	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 35 for description of fields

Figure 33. Velocity Data Format



The number of depth cells is set by the WN-command ([WN – Number of Depth Cells](#)).

The Pathfinder 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 Pathfinder 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 Pathfinder 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 35: Velocity Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Velocity ID	Stores the velocity data identification word (MSB=01h LSB=00h).
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 WN – Number of Depth Cells). These fields follow the same format as listed above for depth cell 1.

Correlation Magnitude, Echo Intensity, Percent-Good, and Status Data Format

BYTE	BIT POSITIONS								
	7/S	6	5	4	3	2	1	0	
1	ID CODE								LSB
2									MSB
3	DEPTH CELL #1, FIELD #1								
4	DEPTH CELL #1, FIELD #2								
5	DEPTH CELL #1, FIELD #3								
6	DEPTH CELL #1, FIELD #4								
7	DEPTH CELL #2, FIELD #1								
8	DEPTH CELL #2, FIELD #2								
9	DEPTH CELL #2, FIELD #3								
10	DEPTH CELL #2, FIELD #4								
↓	(SEQUENCE CONTINUES FOR UP TO 128 BINS)								↓
511	DEPTH CELL #128, FIELD #1								
512	DEPTH CELL #128, FIELD #2								
513	DEPTH CELL #128, FIELD #3								
514	DEPTH CELL #128, FIELD #4								

See Table 36 through Table 39 for a description of the fields.

Figure 34. Correlation Magnitude, Echo Intensity, Percent-Good, and Status Data Format



The number of depth cells is set by the WN-command ([WN – Number of Depth Cells](#)).

Correlation magnitude data give the magnitude of the normalized echo autocorrelation at the lag used for estimating the Doppler phase change. The Pathfinder 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 36: Correlation Magnitude Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the correlation magnitude data identification word (MSB=02h LSB=00h).
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 WN – Number of Depth Cells) for all four beams. These fields follow the same format as listed above for depth cell 1.

The echo intensity scale factor is about 0.61 dB per Pathfinder count. The Pathfinder does not directly check for the validity of echo intensity data.

Table 37: Echo Intensity Data Format

Hex Digit	Binary Byte	Field	Description
1 – 4	1,2	ID Code	Stores the echo intensity data identification word (MSB=03h LSB=00h).
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 WN – Number of Depth Cells) 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 Pathfinder references percent-good data as shown below.

EX-Command	Coordinate System	Velocity 1	Velocity 2	Velocity 3	Velocity 4
00xxx	Beam	Beam 1	BEAM 2	BEAM 3	BEAM 4
Percentage Of Good Pings For:					
EX-Command	Coordinate System	Velocity 1	Velocity 2	Velocity 3	Velocity 4
		Percentage Of:			
01xxx	Instrument	3-Beam	Transformations	More Than One	4-Beam
10xxx	Ship	Transformations	Rejected	Beam Bad In Bin	Transformations
11xxx	Earth	(note 1)	(note 2)		

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, all four beams should 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 2000 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 38: Percent-Good Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the percent-good data identification word (MSB=04h LSB=00h).
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 WN – Number of Depth Cells), 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 39: Status Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the status data identification word (MSB=05h LSB=00h)
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 – Number of Depth Cells) for all four beams. These fields follow the same format as listed above for depth cell 1.

Binary Bottom-Track Data Format

BIT POSITIONS									
BYTE	7/S	6	5	4	3	2	1	0	
1	BOTTOM-TRACK ID								LSB 00h
2									MSB 06h
3	BT PINGS PER ENSEMBLE								LSB
4									MSB
5	RESERVED								LSB
6									MSB
7	BT CORR MAG MIN								
8	BT EVAL AMP MIN								
9	RESERVED								
10	BT MODE								
11	BT ERR VEL MAX								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	BIT POSITIONS							
	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							LSB
46								MSB
47	REF LAYER NEAR							LSB
48								MSB
49	REF LAYER FAR							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							LSB
72								MSB

BYTE	BIT POSITIONS							
	7/S	6	5	4	3	2	1	0
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)							
79	(*SEE BYTE 19)							
80	(*SEE BYTE 21)							
81	(*SEE BYTE 23)							

Figure 35. Binary Bottom-Track Data Format



This data is output only if the BP-command is > 0 and PD0 is selected. See Table 40 for a description of the fields.



The PD0 output data format assumes that the instrument is stationary and the bottom is moving. Pathfinder (Speed Log) output data formats (see [Special Output Data Formats](#)) assume that the bottom is stationary and that the Pathfinder 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 40: Bottom-Track Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the bottom-track data identification word (MSB=06h LSB=00h).
5-8	3,4	BP/BT Pings per ensemble	Stores the number of bottom-track pings to average together in each ensemble (BP – Bottom-Track Pings per Ensemble). If BP = 0, the Pathfinder does not collect bottom-track data. The Pathfinder automatically extends the ensemble interval (TE – Time Per Ensemble) if $BP \times TP > TE$. Scaling: LSD = 1 ping; Range = 1 to 999 pings
9-12	5,6	Reserved	Reserved
13,14	7	BC/BT Corr Mag Min	Stores the minimum correlation magnitude value (BC - Correlation Magnitude Minimum). Scaling: LSD = 1 count; Range = 0 to 255 counts
15,16	8	BA/BT Eval Amp Min	Stores the minimum evaluation amplitude value (BA - Evaluation Amplitude Minimum). Scaling: LSD = 1 count; Range = 1 to 255 counts
17,18	9	Reserved	Reserved
19,20	10	BM/BT Mode	Stores the bottom-tracking mode.

Table 40: Bottom-Track Data Format

Hex Digit	Binary Byte	Field	Description
21-24	11,12	BE/BT Err Vel Max	Stores the error velocity maximum value (BE - Error Velocity Maximum). 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 range from the Pathfinder to the sea bottom (or surface) as determined by each beam. This vertical range does not consider the effects of pitch and roll. When bottom detections are bad, BT Range = 0. 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 coordinate system command setting (EX - Coordinate Transformation). For more information on coordinate transformations, see Beam Coordinate Systems , page 29. 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, Mast, 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 Pathfinder'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 bottom track water-reference layer (BL - Water-Mass Layer Parameters). Scaling (minimum layer size): LSD = 1 dm; Range = 1-999 dm Scaling (near/far boundaries): LSD = 1 dm; Range = 6-9999 dm
101- 116	51-58	Ref Vel/Beam #1-4 Ref Layer Vel	Contains velocity data for the water mass for each beam. Water mass velocities have the same format and scale factor as water-profiling velocities (Table 35). The BL-command explains the water mass.

Table 40: Bottom-Track Data Format

Hex Digit	Binary Byte	Field	Description
117- 124	59-62	RLCM/Bm #1-4 Ref Corr	Contains correlation magnitude data for the water mass for each beam. Water mass correlation magnitudes have the same format and scale factor as water-profiling magnitudes.
125- 132	63-66	RLEI/Bm #1-4 Ref Int	Contains echo intensity data for the Water mass for each beam. Water mass 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 mass for each beam. They indicate the reliability of water mass data. It is the percentage of bottom-track pings that have passed a water mass 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 = 10 to 65535 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 $\approx$ 0.61 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 range from the Pathfinder to the sea bottom (or surface) as determined by each beam. This vertical range does not consider the effects of pitch and roll. When bottom detections are bad, BT Range=0. See bytes 17 through 24 for LSB description and scaling. Scaling: LSD = 65,536 cm, Range = 65,536 to 16,777,215 cm

Environmental Command Parameters Output Format

BIT POSITIONS									
BYTE	7	6	5	4	3	2	1	0	
1	FIXED ATTITUDE ID								LSB 00h
2									MSB 30h
3	ATTITUDE OUTPUT COORDINATES and PROCESSING CONTROL USING INTERPOLATED ATTITUDE (#EE)								
4									
5									
6									
7									
8									
9									
10									
11	RESERVED								
12	FIXED HEADING SCALING (#EH)								
13									
14	FIXED HEADING COORDINATE FRAME (#EH)								
15	ROLL MISALIGNMENT (#EI)								
16									
17	PITCH MISALIGNMENT (#EJ)								
18									
19	USER INPUT FOR PITCH, ROLL, and COORDINATE FRAME (#EP)								
20									
21									
22									
23									
24	USER INPUT FOR UP/DOWN ORIENTATION (#EU)								
25	USER INPUT FOR HEADING BIAS/VARIATION/SYNCHRO OFFSET (#EV)								
26									
27	SENSOR SOURCE (EZ)								↓
↓									
34	TRANSDUCER DEPTH (ED)								
35									
36									
37									
38									

BYTE	BIT POSITIONS							
	7	6	5	4	3	2	1	0
39	SALINITY (ES)							
40	WATER TEMPERATURE (ET)							
41								
42	SPEED OF SOUND (EC)							
43								
44	COORDINATE TRANSFORMATION (EX)							
45	3 BEAM SOLUTION (EX)							
46	BIN MAP (EX)							
47	MSB COORDINATE TRANSFORMATION (EX)							

Figure 36. Environmental Command Parameters Output Format

Environmental Command Parameters correspond to the most useful “E” menu command parameters. The Pathfinder will output Fixed Attitude data as output data (LSBs first). See [Command Descriptions](#) for detailed descriptions of commands used to set these values.

Table 41: Environmental Command Parameters Output Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	FAID / Fixed Attitude ID	Environmental Command Parameters Output word (MSB=30h, LSB=00h).
5-20	3-10	Attitude Output Coordinates	Stores the setting of the #EE command; a user input for the Variable Attitude data to be output (EE - Environmental Data Output).
21,22	11	Reserved	
23-27	12-13	Fixed Heading Scaling	Stores the setting of the #EH command; a user input for heading (EH - Heading).
28	14	Fixed Heading Coordinate Frame	Stores the setting of the #EH command coordinate frame: 1 is ship, 0 is instrument (EH - Heading).
29-32	15,16	Roll Misalignment	Stores the setting of the #EI command; a user input for the roll misalignment (EI - Roll Misalignment Angle).
33-36	17,18	Pitch Misalignment	Stores the setting of the #EJ command; a user input for the pitch misalignment (EJ - Pitch Misalignment Angle).
37-46	19-23	Pitch, Roll and Coordinate Frame	Stores the setting of the #EP command; a user input for the pitch, roll, and coordinate (instrument or ship) frame (EP - Pitch and Roll Angles).
47,48	24	Orientation	Stores the setting of the #EU command; a user input for the up/down orientation (EU - Up/Down Orientation).
49-52	25,26	Heading Offset	Stores the setting of the #EV command; a user input for the heading offset due to heading bias, variation, or synchro initialization (EV - Heading Bias).

Table 41: Environmental Command Parameters Output Format

Hex Digit	Binary Byte	Field	Description
53-68	27-34	Sensor Source	Stores the setting of the EZ command; a user input defining the use of internal, external, or fixed sensors (EZ - Sensor Source).
69-76	35-38	Transducer Depth	Stores the setting of the ED command; a user input defining depth of the transducer (see ED - Depth of Transducer).
77-78	39	Salinity	Stores the setting of the ES command; a user input defining the salinity of the water (see ES – Salinity).
79-82	40,41	Water Temp	Stores the setting of the ET command; a user input defining the temperature of the water (see ET - Temperature).
83-86	42,43	SoS	Stores the setting of the EC command; a user input defining the speed of sound (see EC - Speed of Sound).
87-88	44	Transform	Stores the setting of the right two digits of the EX command that describe the coordinate transformations (see EX – Coordinate Transformation).
89-90	45	3 Beam Solution	Stores the setting of the fourth bit of the EX command that allows 3 beams good (instead of 4) transformations.
91-92	46	Bin Map	Stores the setting of the fifth bit of the EX command that controls bin mapping.
93-94	47	MSB of EX transformation	Stores the setting of the left digit of the EX command that describes the coordinate transformations.

Bottom Track Command Output Format

BYTE	BIT POSITIONS								
	7	6	5	4	3	2	1	0	
1.	BOTTOM TRACK COMMAND ID								LSB 00h
2.									MSB 58h
3.	AMPLITUDE THRESHOLD								
4.	CORRELATION MAGNITUDE								
5.	RESERVED								
6.									
7.	ERROR VELOCITY MAXIMUM								
8.									
9.	DEPTH GUESS								
10.									
11.	RESERVED								
12.	GAIN SWITCH THRESHOLD LOW								
13.	GAIN SWITCH THRESHOLD HIGH								

BYTE	BIT POSITIONS							
	7	6	5	4	3	2	1	0
14.	GAIN SWITCH ALTITUDE							
15.								
16.	WATER MASS LAYER MODE							
17.	WATER MASS LAYER MIN SIZE							
18.								
19.	WATER MASS LAYER NEAR BOUNDARY							
20.								
21.	WATER MASS LAYER FAR BOUNDARY							
22.								
23.	BOTTOM TRACK MODE							
24.	SPEED LOG HOLD TRACK							
25.	SPEED LOG TIME-OUT							
26.								
27.	SPEED LOG FILTER TIME CONSTANT							
28.	PINGS PER ENSEMBLE							
29.								
30.	RESERVED							
31.								
32.								
33.								
34.								
35.								
36.								
37.	BT MAXIMUM TRACKING DEPTH							
38.								
39.	RESERVED							
40.								
41.	TRANSMIT LENGTH							
42.	RESERVED							
43.								

Figure 37. Bottom Track Command Output Data Format

This format is selected via the #BJ command (see [BJ – Data Type Output Control](#)).

Table 42. Bottom Track Command Output Data Format

Binary Byte	Field	Description
1-2	ID	Stores the bottom-track command identification word (MSB=58h LSB=00h)
3	Evaluation Amplitude	Stores the setting of the BA command; Units are 1 to 255 counts (see #BA – Evaluation Amplitude Minimum)
4	Correlation Magnitude	Stores the setting of the BC command; Units are 0 to 255 counts (see #BC – Correlation Magnitude Minimum)
5-6	Reserved	Reserved
7-8	Error Velocity Maximum	Stores the setting of the BE command; Units are 0 to 9999 mm/s (see #BE – Error Velocity Maximum)
9-10	Depth Guess	Stores the setting of the BF command; Units are 1 to 65535 dm (0 for automatic search) (see #BF – Depth Guess)
11	Reserved	Reserved
12	Gain Threshold Low	Stores the setting of the #BH command low threshold; Units are 0 to 255 counts (see #BH – Gain Switch Threshold)
13	Gain Threshold High	Stores the setting of the #BH command high threshold; Units are 0 to 255 counts (see #BH – Gain Switch Threshold)
14-15	Gain Switch Altitude	Stores the setting of the #BI command; Units are 0 to 25 meters (300 kHz), 0 to 3 meters (600 kHz) (see #BI – Gain Switch Altitude)
16	Water Mass Layer Mode	Stores the setting of the #BK command; Setting are 0 to 3 [0=off, 1=WB, 2=LostB, 3=W] (see #BK – Water-Mass Layer Mode)
17-18	Water Mass Layer Min Size	Stores the setting of the #BL command; Setting are 1 to 999 dm (see #BL – Water-Mass Layer Parameters)
19-20	Water Mass Layer Near Boundary	Stores the setting of the #BL command; Setting are 6 to 9999 dm (see #BL – Water-Mass Layer Parameters)
21-22	Water Mass Layer Far Boundary	Stores the setting of the #BL command; Setting are 7 to 9999 dm (see #BL – Water-Mass Layer Parameters)
23	Bottom Track Mode	Stores the setting of the #BM command; Setting are 8 or 9 (see #BM – Bottom Mode)
24	Speed Log Hold	Stores the setting of the #BN command; Hold Distance or zero if timeout (see #BN – Speed Log Hold/Drop Control)
25-26	Speed Log Drop Control	Stores the setting of the #BN command; Speed log time-out units in 0 to 999 seconds (see #BN – Speed Log Hold/Drop Control)
27	Speed Log Time Constant	Stores the setting of the #BO command; Settings are 0 to 100 (see #BO – Distance Measure Filter Constant)
28-29	Pings Per Ensemble	Stores the setting of the BP command; Setting are 0 to 999 pings (see BP – Bottom-Track Pings per Ensemble)
30 - 36	Reserved	Reserved

Table 42. Bottom Track Command Output Data Format

Binary Byte	Field	Description
37-38	Maximum Tracking Depth	Stores the setting of the BX command; Setting are 10 to 65535 dm (see BX – Maximum Tracking Depth)
39 - 40	Reserved	Reserved
41	Transmit Length	Stores the setting of the #BY command; Setting are 0 to 100% (see #BY – Transmit Length)
42-43	Reserved	Reserved

Bottom Track High Resolution Velocity Format

BIT POSITIONS									
BYTE	7	6	5	4	3	2	1	0	
1.	BOTTOM TRACK HIGH RESOLUTION VELOCITY ID								LSB 03h
2.									MSB 58h
3.	BT VELOCITY 1								
4.									
5.									
6.									
7.	BT VELOCITY 2								
8.									
9.									
10.									
11.	BT VELOCITY 3								
12.									
13.									
14.									
15.	BT VELOCITY 4								
16.									
17.									
18.									
19.	BT DISTANCE MADE GOOD 1								
20.									
21.									
22.									

BYTE	BIT POSITIONS								
	7	6	5	4	3	2	1	0	
23.	BT DISTANCE MADE GOOD 2								
24.									
25.									
26.									
27.	BT DISTANCE MADE GOOD 3								
28.									
29.									
30.									
31.	BT DISTANCE MADE GOOD 4								
32.									
33.									
34.									
35.	WATER MASS VELOCITY 1								
36.									
37.									
38.									
39.	WATER MASS VELOCITY 2								
40.									
41.									
42.									
43.	WATER MASS VELOCITY 3								
44.									
45.									
46.									
47.	WATER MASS VELOCITY 4								
48.									
49.									
50.									
51.	WATER MASS DISTANCE MADE GOOD 1								
52.									
53.									
54.									

BYTE	BIT POSITIONS							
	7	6	5	4	3	2	1	0
55.	WATER MASS DISTANCE MADE GOOD 2							
56.								
57.								
58.								
59.	WATER MASS DISTANCE MADE GOOD 3							
60.								
61.								
62.								
63.	WATER MASS DISTANCE MADE GOOD 4							
64.								
65.								
66.								
67.	SPEED OF SOUND							
68.								
69.								
70.								

Figure 38. Bottom Track High Resolution Velocity Output Format



The sign of the bottom track and water mass layer velocities in the Bottom Track High Resolution Velocity Format indicate the direction the DVL or vessel is moving with respect to a stationary bottom and is the opposite sign of the velocities in the [Binary Bottom Track Data Format](#).

This format is selected via the #BJ command (see [BJ – Data Type Output Control](#)).

Table 43: Bottom Track High Resolution Velocity Output Format

Binary Byte	Field	Description
1-2	ID	PD0 ID (MSB=58h LSB=03h)
3-6	BT Velocity 1	Bottom Track Axis 1 Velocity in 0.01mm/s. Reference frame dependent on EX – Coordinate Transformation .
7-10	BT Velocity 2	Bottom Track Axis 2 Velocity in 0.01mm/s. Reference frame dependent on EX command.
11-14	BT Velocity 3	Bottom Track Axis 3 Velocity in 0.01mm/s. Reference frame dependent on EX command.
15-18	BT Velocity 4	Bottom Track Axis 4 Velocity in 0.01mm/s. Reference frame dependent on EX command.

Table 43: Bottom Track High Resolution Velocity Output Format

Binary Byte	Field	Description
19-22	BT DMG 1	Bottom Track Axis 1 Distance in 0.01mm made good. Reference frame dependent on EX command.
23-26	BT DMG 2	Bottom Track Axis 2 Distance in 0.01mm made good. Reference frame dependent on EX command.
27-30	BT DMG 3	Bottom Track Axis 3 Distance in 0.01mm made good. Reference frame dependent on EX command.
31-34	BT DMG 4	Bottom Track Axis 4 Distance in 0.01mm made good. Reference frame dependent on EX command.
35-38	WM Velocity 1	Water Mass Axis 1 Velocity in 0.01mm/s. Reference frame dependent on EX command.
39-42	WM Velocity 2	Water Mass Axis 2 Velocity in 0.01mm/s. Reference frame dependent on EX command.
43-46	WM Velocity 3	Water Mass Axis 3 Velocity in 0.01mm/s. Reference frame dependent on EX command.
47-50	WM Velocity 4	Water Mass Axis 4 Velocity in 0.01mm/s. Reference frame dependent on EX command.
51-54	WM DMG 1	Water Mass Axis 1 Distance in 0.01mm made good. Reference frame dependent on EX command.
55-58	WM DMG 2	Water Mass Axis 2 Distance in 0.01mm made good. Reference frame dependent on EX command.
59-62	WM DMG 3	Water Mass Axis 3 Distance in 0.01mm made good. Reference frame dependent on EX command.
63-66	WM DMG 4	Water Mass Axis 4 Distance in 0.01mm made good. Reference frame dependent on EX command.
67-70	SoS	Speed of Sound * 10^6 .

Bottom Track Range Format

BIT POSITIONS									
BYTE	7	6	5	4	3	2	1	0	
1.	BOTTOM TRACK RANGE ID								LSB 04h
2.									MSB 58h
3.	Slant Range								
4.									
5.									
6.									
7.	Axis Delta Range								
8.									
9.									
10.									
11.	Vertical Range								
12.									
13.									
14.									
15.	% Good 4 Bm								
16.	% Good Bm 1&2								
17.	% Good Bm 3 & 4								
18.	BEAM 1 Raw Range								
19.									
20.									
21.									
22.	BEAM 2 Raw Range								
23.									
24.									
25.									
26.	BEAM 3 Raw Range								
27.									
28.									
29.									

BYTE	BIT POSITIONS							
	7	6	5	4	3	2	1	0
30.	BEAM 4 Raw Range							
31.								
32.								
33.								
34.	BEAM 1 Raw Max BT Filter							
35.	BEAM 2 Raw Max BT Filter							
36.	BEAM 3 Raw Max BT Filter							
37.	BEAM 4 Raw Max BT Filter							
38.	BEAM 1 RAW MAX BT AMPLITUDE							
39.	BEAM 2 RAW MAX BT AMPLITUDE							
40.	BEAM 3 RAW MAX BT AMPLITUDE							
41.	BEAM 4 RAW MAX BT AMPLITUDE							

Figure 39. Bottom Track Range Output Data Format

This data type is output when selecting PD0 and the High Accuracy Bottom Track feature is installed (see [OL – Display Feature List](#)) and then selected via the #BJ command (see [BJ – Data Type Output Control](#)).

Table 44: Bottom Track Range Output Data Format

Binary Bytes	Field	Description
1-2	ID	PD0 ID (MSB=58h LSB=04h)
3-6	Slant Range	Average range to bottom along the Z axis of the instrument frame, averaged over the ensemble. Valid only for at least 2 beams good on axis; zero is output for invalid data. Units are 0.1mm.
7-10	Axis Delta Range	Difference in slant range between beam 1 & 2 estimate and beam 3 & 4 estimate averaged over the ensemble. Valid only for 4 beam good pings. Units are 0.1mm.
11-14	Vertical Range	Average vertical range (altitude) of bottom depth (accounting for instrument tilt) over the ensemble. Zero is output if vertical range cannot be calculated because less than three beams are good, etc. Units are 0.1mm.
15	% Good 4 Bm	Percent Good 2 axis (4 Bm) slant range solutions.
16	% Good Bm 1&2	Percent Good axis Bm 1 & 2 slant range solutions.
17	% Good Bm 3 & 4	Percent Good axis Bm 3 & 4 slant range solutions.
18-21	BM 1 Raw Range	Slant range to the bottom along beam 1 multiplied by cos(Janus), averaged over the ensemble, even if fewer than 3 beams detect the bottom. Units 0.1mm

Table 44: Bottom Track Range Output Data Format

Binary Bytes	Field	Description
22-25	BM 2 Raw Range	Slant range to the bottom along beam 2 multiplied by $\cos(\text{Janus})$, averaged over the ensemble, even if fewer than 3 beams detect the bottom. Units 0.1mm
26-29	BM 3 Raw Range	Slant range to the bottom along beam 3 multiplied by $\cos(\text{Janus})$, averaged over the ensemble, even if fewer than 3 beams detect the bottom. Units 0.1mm
30-33	BM 4 Raw Range	Slant range to the bottom along beam [n] multiplied by $\cos(\text{Janus})$, averaged over the ensemble, even if fewer than 3 beams detect the bottom. Units 0.1mm
34	BM 1 Raw Max BT Filter	Maximum Bottom detection filter output in counts averaged over the ensemble for beam 1 even if less than 3 beams detecting bottom.
35	BM 2 Raw Max BT Filter	Maximum Bottom detection filter output in counts averaged over the ensemble for beam 2 even if less than 3 beams detecting bottom.
36	BM 3 Raw Max BT Filter	Maximum Bottom detection filter output in counts averaged over the ensemble for beam 3 even if less than 3 beams detecting bottom.
37	BM 4 Raw Max BT Filter	Maximum Bottom detection filter output in counts averaged over the ensemble for beam 4 even if less than 3 beams detecting bottom.
38	BM 1 Raw Max BT Amp	Bottom amplitude at measured range in counts, averaged over the ensemble, for beam 1 even if fewer than 3 beams detect the bottom. Amplitude value corresponds to the middle of the bottom return.
39	BM 2 Raw Max BT Amp	Bottom amplitude at measured range in counts, averaged over the ensemble, for beam 2 even if fewer than 3 beams detect the bottom. Amplitude value corresponds to the middle of the bottom return.
40	BM 3 Raw Max BT Amp	Bottom amplitude at measured range in counts, averaged over the ensemble, for beam 3 even if fewer than 3 beams detect the bottom. Amplitude value corresponds to the middle of the bottom return.
41	BM 4 Raw Max BT Amp	Bottom amplitude at measured range in counts, averaged over the ensemble, for beam 4 even if fewer than 3 beams detect the bottom. Amplitude value corresponds to the middle of the bottom return.

Navigation Parameters Data Format

BYTE	BIT POSITIONS								
	7	6	5	4	3	2	1	0	
1	ID_NAV_PARAMS								LSB 13h
2									MSB 20h
3	TIME-TO-BOTTOM BEAM 1								LSB
4									
5									
6									MSB
7	TIME-TO-BOTTOM BEAM 2								LSB
8									
9									
10									MSB
11	TIME-TO-BOTTOM BEAM 3								LSB
12									
13									
14									MSB
15	TIME-TO-BOTTOM BEAM 4								LSB
16									
17									
18									MSB
19	BOTTOM TRACK STANDARD DEVIATION BEAM 1								LSB
20									MSB
21	BOTTOM TRACK STANDARD DEVIATION BEAM 2								LSB
22									MSB
23	BOTTOM TRACK STANDARD DEVIATION BEAM 3								LSB
24									MSB
25	BOTTOM TRACK STANDARD DEVIATION BEAM 4								LSB
26									MSB
27	SHALLOW OPERATION FLAG								
28	TIME-TO-WATER MASS LAYER BEAM 1								LSB
29									
30									
31									MSB

BYTE	BIT POSITIONS								
	7	6	5	4	3	2	1	0	
32	TIME-TO-WATER MASS LAYER BEAM 2								LSB
33									
34									
35									MSB
36	TIME-TO-WATER MASS LAYER BEAM 3								LSB
37									
38									
39									MSB
40	TIME-TO-WATER MASS LAYER BEAM 4								LSB
41									
42									
43									MSB
44	RANGE TO WATER MASS CELL								LSB
45									MSB
46	WATER TRACK STANDARD DEVIATION BEAM 1								LSB
47									MSB
48	WATER TRACK STANDARD DEVIATION BEAM 2								LSB
49									MSB
50	WATER TRACK STANDARD DEVIATION BEAM 3								LSB
51									MSB
52	WATER TRACK STANDARD DEVIATION BEAM 4								LSB
53									MSB
54	BOTTOM TRACK TIME OF VALIDITY BEAM 1								LSB
55									
56									
57									MSB
58	BOTTOM TRACK TIME OF VALIDITY BEAM 2								LSB
59									
60									
61									MSB

BYTE	BIT POSITIONS								
	7	6	5	4	3	2	1	0	
62	BOTTOM TRACK TIME OF VALIDITY BEAM 3								LSB
63									
64									
65									MSB
66	BOTTOM TRACK TIME OF VALIDITY BEAM 4								LSB
67									
68									
69									MSB
70	WATER TRACK TIME OF VALIDITY BEAM 1								LSB
71									
72									
73									MSB
74	WATER TRACK TIME OF VALIDITY BEAM 2								LSB
75									
76									
77									MSB
78	WATER TRACK TIME OF VALIDITY BEAM 3								LSB
79									
80									
81									MSB
82	WATER TRACK TIME OF VALIDITY BEAM 4								LSB
83									
84									
85									MSB

Figure 40. Navigation Parameters Data Format

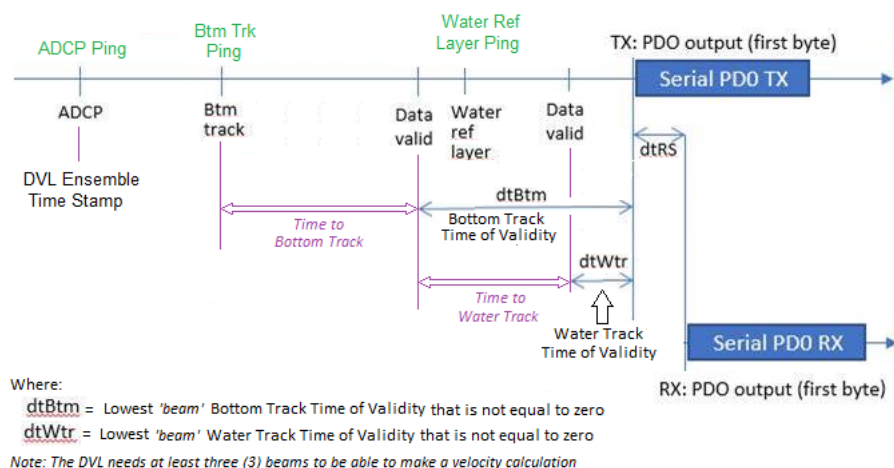
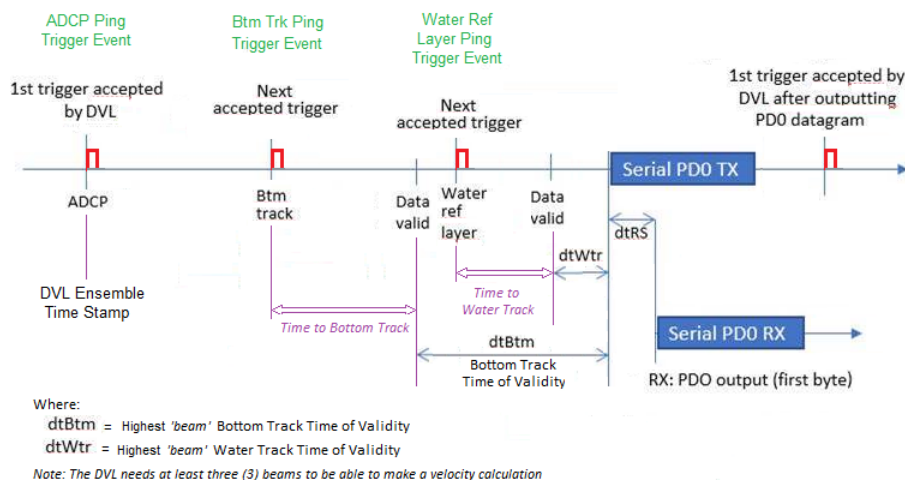
This data type is output when selecting PDO and the High Accuracy Bottom Track feature is installed (see [OL – Display Feature List](#)) and then selected via the #BJ command (see [BJ – Data Type Output Control](#)).

Table 45. Navigation Parameters Data Format

Hex Digit	Binary Byte	Field	Description																
1-4	1, 2	ID_NAV_PARAMS / Navigation Parameters ID	Stores the navigation parameters identification word, ID_NAV_PARAMS, (MSB=20h LSB=13h)																
5-36	3-18	TIME-TO-BOTTOM BEAMS 1-4	Stores T_{bot} , the time interval between the DVL Ensemble/hardware trigger and the center time, or “time the ping hits the bottom,” of the bottom track measurement for Beams 1-4 (see Figure 41 and Figure 42). Unit is 8 carrier cycles (52.08 μ s for 153.6 kHz). Unsigned integer.																
<table border="1"> <thead> <tr> <th>DVL Type</th><th>Frequency</th><th>Carrier Cycle</th><th>8 x Carrier Cycles</th></tr> </thead> <tbody> <tr> <td>600</td><td>614.4 KHz</td><td>1.628 uSec</td><td>13.02 uSec</td></tr> <tr> <td>300</td><td>307.2 KHz</td><td>3.255 uSec</td><td>26.04 uSec</td></tr> <tr> <td>150</td><td>153.6 KHz</td><td>6.510 uSec</td><td>52.08 uSec</td></tr> </tbody> </table>				DVL Type	Frequency	Carrier Cycle	8 x Carrier Cycles	600	614.4 KHz	1.628 uSec	13.02 uSec	300	307.2 KHz	3.255 uSec	26.04 uSec	150	153.6 KHz	6.510 uSec	52.08 uSec
DVL Type	Frequency	Carrier Cycle	8 x Carrier Cycles																
600	614.4 KHz	1.628 uSec	13.02 uSec																
300	307.2 KHz	3.255 uSec	26.04 uSec																
150	153.6 KHz	6.510 uSec	52.08 uSec																
37-52	19-26	BOTTOM TRACK STD DEVIATION BEAMS 1-4	Stores a prediction of the single ping bottom-track standard deviation calculated with the velocity variance model. Units are mm/sec.																
53	27	SHALLOW OPERATION FLAG	Stores the flag indicating whether the Pathfinder is operating in shallow mode or not. If this value is set to 1, then the Pathfinder is operating in shallow mode with one beam pinging at a time. If this value is 0, then the Pathfinder is operating in Deep Mode with all beams pinging at the same time.																
54-86	28-43	TIME-TO-WATER MASS BEAMS 1-4	Stores T_{wm} , the time interval between the hardware trigger (defined by the CX command) and the center time, or “time the ping hits the center of the water mass layer,” of the water mass measurement for Beams 1-4. Unit is 8 carrier cycles (52.08 μ s for 153.6 kHz). Unsigned integer.																
87-90	44-45	RANGE TO WATER MASS CELL	The range to the water mass cell being tracked. Units are in carrier cycles (6.51 μ s for 153.6 kHz).																
91-106	46-53	WATER TRACK STD DEVIATION BEAMS 1-4	Stores a prediction of the single ping water-track standard deviation calculated with the velocity variance model. Units are mm/sec.																
107-138	54-69	BOTTOM TRACK TIME OF VALIDITY BEAMS 1-4	Stores the time elapsed between when the bottom track echo is centered on the bottom and the first character in the PDO sentence. Unit is 1 μ sec. Accuracy is within $\pm$ 5msec. Unsigned integer. Note the value will be set to zero if the bottom track velocity for the corresponding beam is bad.																

Table 45. Navigation Parameters Data Format

Hex Digit	Binary Byte	Field	Description
139-170	70-85	WATER TRACK TIME OF VALIDITY BEAMS 1-4	Stores the time elapsed between when the water mass layer echo is centered on the tracking bin and the first character in the PDO sentence. Unit is 1µsec. Accuracy is within ± 5 msec. Unsigned integer. Note the value will be set to zero if the bottom track velocity for the corresponding beam is bad.

**Figure 41. No Trigger Timing****Figure 42. External Trigger Timing**

Sensor Source for Doppler Processing Format

BIT POSITIONS									
BYTE	7	6	5	4	3	2	1	0	
1.	SENSOR SOURCE FOR DOPPLER PROCESSING FORMAT ID								01h LSB
2.									30h MSB
3.	HEADING								
4.									
5.									
6.									
7.	HEADING STATUS								
8.	HEADING SOURCE								
9.									
10.	PITCH								
11.									
12.									
13.									
14.	PITCH STATUS								
15.	PITCH SOURCE								
16.									
17.	ROLL								
18.									
19.									
20.									
21.	ROLL STATUS								
22.	ROLL SOURCE								
23.									
24.	SOS								
25.									
26.									
27.									
28.	SOS STATUS								
29.	SOS SOURCE								
30.									
31.	TEMPERATURE								

BYTE	BIT POSITIONS							
	7	6	5	4	3	2	1	0
32.								
33.								
34.								
35.	TEMPERATURE STATUS							
36.	TEMPERATURE SOURCE							
37.								
38.								
39.	SALINITY							
40.								
41.								
42.	SALINITY STATUS							
43.	SALINITY SOURCE							
44.								
45.								
46.	DEPTH							
47.								
48.								
49.	DEPTH STATUS							
50.	DEPTH SOURCE							
51.								
52.								
53.	PRESSURE							
54.								
55.								
56.	PRESSURE STATUS							
57.	PRESSURE SOURCE							
58.								
59.								
60.	ENSEMBLE TIMER TICKS							
61.								
62.								

Figure 43. Sensor Source for Doppler Processing Output Format

This format is selected via the #EE command (see [EE - Environmental Data Output](#)).

Table 46: Sensor Source for Doppler Processing Output Format

Binary Bytes	Field	Description
1-2	ID	PD0 ID (MSB=30h LSB=01h)
3-6	Heading	Heading in 1/100ths of a degree.
7	Heading Status	A value of 0 indicates no valid data; 1 indicates sensor data valid from sensor specified by EZ - Sensor Source ; A value of 2 indicates sensor data valid from alternate sensor or user input.
8-9	Heading Source	See notes, below.
10-13	Pitch	Pitch in 1/100ths of a degree.
14	Pitch Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.
15-16	Pitch Source	See notes, below.
17-20	Roll	Roll in 1/100ths of a degree.
21	Roll Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.
22-23	Roll Source	See notes, below.
24-27	SOS	Speed of Sound 1/100ths of a m/s.
28	SOS Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.
29-30	SOS Source	See notes, below.
31-34	Temperature	Temperature in 1/100ths of a °C.
35	Temperature Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.
36-37	Temperature Source	See notes, below.
38-41	Salinity	Salinity in parts-per-ten thousand
42	Salinity Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.
43-44	Salinity Source	See notes, below.
45-48	Depth	Depth in centimeters
49	Depth Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.

Table 46: Sensor Source for Doppler Processing Output Format

Binary Bytes	Field	Description
50-51	Depth Source	See notes, below.
52-55	Pressure	Pressure in kPa.
56	Pressure Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.
57-58	Pressure Source	See notes, below.
59-62	Ensemble Timer Ticks	Timer Ticks Recorded when the RTC clock was read at the start of the ensemble. Intended for use in matching sensor TimeTags to RTC based ensemble time.



This data corresponds to the last ping of the ensemble for those sensors sampled at ping intervals. It is intended for single ping ensembles.

Output of this data is controlled by the 7th bit of the EE command ([EE - Environmental Data Output](#)).

The sensor source is identified by the detailed list of sensors in the table of the main text or the #EY description ([EY – Sensor Source Override for Doppler Parameters](#)). In addition to the sensors in that command, a sensor ID of -1 indicates that the parameter has been calculated based on other parameters (for example, speed of sound calculated based on salinity, pressure and temperature). A sensor ID of 0 indicates the parameter is from a user input command.

Binary Checksum Data Format

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

Figure 44. Binary Checksum Data Format**Table 47: Checksum Data Format**

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Checksum Data	This field contains a modulo 65536 checksum. If the sum is 12345678, then it is divided by 65536, and the remainder is output; For example, $12345678 / 65536 = 188.3800964 = 188 + 24910/65536$, so the number 24910, converted to hex as 614E would be output. An easier way to compute the checksum is using the sum 12345678; converted to hex it is the number 00BC614E. The least-significant four hex digits are output; i.e. 614E.

Special Output Data Formats

The PD4, PD5, PD6 and PD13 commands select the desired Pathfinder (speed log) output data format.

The Pathfinder 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 Pathfinder collects all data in the output buffer during an ensemble.

Figure 45 through Figure 46 shows the format of these buffers and the sequence in which the Pathfinder sends the data. Table 48 through Table 50 lists the format, bytes, fields, scaling factors, and a detailed description of every item in the Pathfinder binary output buffers.



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



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 PD4, 5, 6, and 13 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.



For more information on coordinate transformations, see [Beam Coordinate Systems](#), page 29.

Pathfinder Binary Data Format (PD4/PD5)

Byte	BIT POSITION								
	7	6	5	4	3	2	1	0	
1	Pathfinder 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									

Byte	BIT POSITION							
	7	6	5	4	3	2	1	0
29	E-VEL REF LAYER							
30								
31	REF LAYER START							
32								
33	REF LAYER END							
34								
35	REF LAYER STATUS							
36	TOFP-HOUR							
37	TOFP-MINUTE							
38	TOFP-SECOND							
39	TOFP-HUNDREDTHS							
40	BIT RESULTS							
41								
42	SPEED OF SOUND							
43								
44	TEMPERATURE							
45								
46	CHECKSUM							
47								

Figure 45. Pathfinder Binary Data Format (PD4/PD5)



*IF 0, THEN PD4 (BYTES 1-47)

*IF 1, THEN PD5 (BYTES 1-45 + Table 49)

Pathfinder Output Data Format (PD4/PD5) Details

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

Table 48: Pathfinder Output Data Format (PD4/PD5) Details

Hex Digit	Binary Byte	Field	Description																														
1,2	1	Pathfinder Data ID	Stores the Pathfinder (speed log) identification word (7Dh).																														
3,4	2	Data Structure	Identifies which data pattern will follow based on the PD-command (PD0 Output Data Format). 0 = PD4 = Bytes 1 through 47 from Figure 45. 1 = PD5 = Bytes 1 through 45 from Figure 45 and bytes 46 through 88 from Figure 46.																														
5-8	3,4	No. of Bytes	Contains the number of bytes sent in this data structure, not including the final checksum.																														
9,10	5	System Config	Defines the Pathfinder 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 xxxxx001 150-kHz Pathfinder xxxxx010 300-kHz Pathfinder xxxxx011 600-kHz Pathfinder xxxxx100 1200-kHz Pathfinder																														
11-14	6,7	X-Vel Btm	These fields contain the velocity of the vessel in relation to the bottom in mm/s. The setting of the EX-command (Coordinate Transformation) determines how the Pathfinder references the velocity data .																														
15-18	8,9	Y-Vel Btm																															
19-22	10,11	Z-Vel Btm																															
23-26	12,13	E-Vel Btm																															
			<table><tr><th>EX-CMD</th><th>COORD SYS</th><th>Velocity 1</th><th>Velocity 2</th><th>Velocity 3</th><th>Velocity 4</th></tr><tr><td>xxx00xxx</td><td>Beam</td><td>To Beam 1</td><td>To Beam 2</td><td>To Beam 3</td><td>To Beam 4</td></tr><tr><td>xxx01xxx</td><td>Instrument</td><td>Bm1-Bm2</td><td>Bm4-Bm3</td><td>To Xducer</td><td>Err Vel</td></tr><tr><td>xxx10xxx</td><td>Ship</td><td>Port-Stbd</td><td>Aft-Fwd</td><td>To Surface</td><td>Err Vel</td></tr><tr><td>xxx11xxx</td><td>Earth</td><td>To East</td><td>To North</td><td>To Surface</td><td>Err Vel</td></tr></table> Positive values indicate water movement (see notes at end of this table).	EX-CMD	COORD SYS	Velocity 1	Velocity 2	Velocity 3	Velocity 4	xxx00xxx	Beam	To Beam 1	To Beam 2	To Beam 3	To Beam 4	xxx01xxx	Instrument	Bm1-Bm2	Bm4-Bm3	To Xducer	Err Vel	xxx10xxx	Ship	Port-Stbd	Aft-Fwd	To Surface	Err Vel	xxx11xxx	Earth	To East	To North	To Surface	Err Vel
EX-CMD	COORD SYS	Velocity 1	Velocity 2	Velocity 3	Velocity 4																												
xxx00xxx	Beam	To Beam 1	To Beam 2	To Beam 3	To Beam 4																												
xxx01xxx	Instrument	Bm1-Bm2	Bm4-Bm3	To Xducer	Err Vel																												
xxx10xxx	Ship	Port-Stbd	Aft-Fwd	To Surface	Err Vel																												
xxx11xxx	Earth	To East	To North	To Surface	Err Vel																												
27-30	14,15	Bm1	These fields contain the vertical range from the Pathfinder 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 (300 and 150 kHz) Scaling: LSD = 1 decimeter; Range = 0 to 65535 dm (38 kHz)																														
31-34	16,17	Bm2 Rng to																															
35-38	18,19	Bm3 Bottom																															
39-42	20,21	Bm4																															

Table 48: Pathfinder Output Data Format (PD4/PD5) Details

Hex Digit	Binary Byte	Field	Description																														
43,44	22	Bottom Status	This field shows the status of bottom-referenced correlation and echo amplitude data. Convert to binary and interpret as follows. A zero code indicates status is OK. <pre>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</pre>																														
45-48	23,24	Velocity 1	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 Pathfinder references the velocity data. <table><thead><tr><th>EX-CMD</th><th>COORD SYS</th><th>Velocity 1</th><th>Velocity 2</th><th>Velocity 3</th><th>Velocity 4</th></tr></thead><tbody><tr><td>xxx00xxx</td><td>Beam</td><td>To Beam 1</td><td>To Beam 2</td><td>To Beam 3</td><td>To Beam 4</td></tr><tr><td>xxx01xxx</td><td>Instrument</td><td>Bm1-Bm2</td><td>Bm4-Bm3</td><td>To Xducer</td><td>Err Vel</td></tr><tr><td>xxx10xxx</td><td>Ship</td><td>Port-Stbd</td><td>Aft-Fwd</td><td>To Surface</td><td>Err Vel</td></tr><tr><td>xxx11xxx</td><td>Earth</td><td>To East</td><td>To North</td><td>To Surface</td><td>Err Vel</td></tr></tbody></table> Positive values indicate water movement (see notes at end of this table).	EX-CMD	COORD SYS	Velocity 1	Velocity 2	Velocity 3	Velocity 4	xxx00xxx	Beam	To Beam 1	To Beam 2	To Beam 3	To Beam 4	xxx01xxx	Instrument	Bm1-Bm2	Bm4-Bm3	To Xducer	Err Vel	xxx10xxx	Ship	Port-Stbd	Aft-Fwd	To Surface	Err Vel	xxx11xxx	Earth	To East	To North	To Surface	Err Vel
EX-CMD	COORD SYS	Velocity 1		Velocity 2	Velocity 3	Velocity 4																											
xxx00xxx	Beam	To Beam 1		To Beam 2	To Beam 3	To Beam 4																											
xxx01xxx	Instrument	Bm1-Bm2		Bm4-Bm3	To Xducer	Err Vel																											
xxx10xxx	Ship	Port-Stbd		Aft-Fwd	To Surface	Err Vel																											
xxx11xxx	Earth	To East	To North	To Surface	Err Vel																												
49-52	25,26	Velocity 2																															
53-56	27,28	Velocity 3																															
57-60	29,30	Velocity 4																															
61-64	31,32	Ref Layer Start	These fields contain the starting boundary (near surface) and the ending boundary (near bottom) of the water-mass layer (BL-command). If the minimum size field is zero, the Pathfinder does not calculate water mass data. Scaling: LSD = 1 dm; Range = 0-9999 dm																														
65-68	33,34	Ref Layer End																															
69,70	35	Ref Layer Status	This field shows the status of water mass depth and correlation data. Convert to binary and interpret as follows. A zero code indicates status is OK. <pre>BIT 76543210 xxx1xxxx ALTITUDE IS TOO SHALLOW xxxx1xxx BEAM 4 LOW CORRELATION xxxxxx1xx BEAM 3 LOW CORRELATION xxxxxxx1x BEAM 2 LOW CORRELATION xxxxxxx1 BEAM 1 LOW CORRELATION</pre>																														
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																															

Table 48: Pathfinder Output Data Format (PD4/PD5) Details

Hex Digit	Binary Byte	Field	Description
79-82	40,41	BIT Results	Status for leak sensors <pre> BITS 07 06 05 04 03 02 01 00 x x x x x x x 1 Sensor A leak detected x x x x x x 1 x Sensor A open circuit x x x x x 1 x x Sensor B leak detected x x x x 1 x x x Sensor B open circuit </pre> Upper byte (byte 41) is unused
83-86	42,43	Speed of Sound	Contains either manual or calculated speed of sound information (EC - Speed of Sound). 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 Pathfinder 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 49.



The Pathfinder packs velocity data into a two-byte, two's-complement integer [-32768, 32767] with the LSB sent first. The Pathfinder scales velocity data in millimeters per second (mm/s). A value of -32768 (8000h) indicates a bad velocity.

Bottom or reference-layer velocities will be all valid or all invalid. That is, if the X-velocity is valid then the Y and Z-velocities are valid; if X is not valid, Y and Z are not valid.

The Pathfinder allows 3-beam transformations when the fourth beam is invalid. If a 3-beam solution is output, the error velocity will be marked bad (since it can't be computed without four good beams). This is how you can tell, as all transformed velocity outputs include error velocity. However, there won't be any indication of which beam was bad.

Pathfinder Binary Data Format (PD5)

Byte	BIT POSITION								
	7	6	5	4	3	2	1	0	
46	SALINITY								
47	DEPTH								LSB
48									MSB
49	PITCH								LSB
50									MSB
51	ROLL								LSB
52									MSB
53	HEADING								LSB
54									MSB
55	DISTANCE MADE GOOD/BTM (EAST)								LSB
56									
57									
58									MSB
59	DISTANCE MADE GOOD/BTM (NORTH)								LSB
60									
61									
62									MSB
63	DISTANCE MADE GOOD/BTM (UP)								LSB
64									
65									
66									MSB
67	DISTANCE MADE GOOD/BTM (ERROR)								LSB
68									
69									
70									MSB
71	DISTANCE MADE GOOD/REF (EAST)								LSB
72									
73									
74									MSB

Byte	BIT POSITION								
	7	6	5	4	3	2	1	0	
75	DISTANCE MADE GOOD/REF (NORTH)								LSB
76									
77									
78									MSB
79	DISTANCE MADE GOOD/REF (UP)								LSB
80									
81									
82									MSB
83	DISTANCE MADE GOOD/REF (ERROR)								LSB
84									
85									
86									MSB
87	CHECKSUM								LSB
88									MSB

Figure 46. Pathfinder Binary Data Format (PD5)

Pathfinder Output Data Format (PD5) Details

The Pathfinder sends this data format (Figure 45 and Figure 46) only when the PD5 command is used. Table 48 explains the first part of this data structure.

Table 49: Pathfinder 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 – Salinity). 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 - Depth of Transducer). 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 Pathfinder pitch angle (EP - Pitch and Roll Angles). 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 Pathfinder roll angle (ER - Roll Angle). This value may be a manual setting or a reading from a tilt sensor. For an up-facing Pathfinder system, positive values mean that Beam #2 is spatially higher than Beam #1. For a down-facing Pathfinder system, 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 Pathfinder heading angle (EH - Heading). This value may be a manual setting or a reading from a heading sensor. Scaling: LSD = 0.01 degree; Range = 000.00 to 359.99 degrees
109-116	55-58	DMG/Btm East	These fields contain the Distance Made Good (DMG) over the bottom since the time of the first ping after initialization or <BREAK>. Where: (DMG X) = (Sum of all X's) (DMG Y) = (Sum of all Y's) (DMG Z) = (Sum of all Z's) Scaling: LSD = 1 dm; Range = -10,000,000 to 10,000,000 mm
117-124	59-62	DMG/Btm	
125-132	63-66	North	
133-140	67-70	DMG/Btm Up DMG/Btm Error	
141-148	71-74	DMG/Ref East	These fields contain the distance made good over the water-mass layer since the time of the first ping after initialization or <BREAK>. Where: (DMG X) = (Sum of all X's) (DMG Y) = (Sum of all Y's) (DMG Z) = (Sum of all Z's) Scaling: LSD = 1 dm; Range = -10,000,000 to 10,000,000 mm
149-156	75-78	DMG/Ref North	
157-164	79-82	DMG/Ref Up	
165-172	83-86	DMG/Ref Error	
173-176	87,88	Checksum	This field contains a modulo 65536 checksum. The Pathfinder computes the checksum by summing all the bytes in the output buffer excluding the checksum.

Pathfinder Output Data Format (PD6)

The Pathfinder sends this data format only when the PD6 command is used. The Pathfinder outputs data in the following line order. Note that not all data items may be displayed. Examples: (1) If #BK = zero, the Pathfinder does not send water-mass data (line items beginning with W); (2) If #BK = three, the Pathfinder does not send bottom-track data (line items beginning with B).

Table 50: Pathfinder 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,YMMDDHHmmsssh,SS.S,+TT.T,DDDD.D,CCCC.C,BBB <CR><LF> where: YMMDDHHmmsssh = 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 where the first B on the left is the number of BIT errors (MSB) and the last 2 BB (LSB) are the actual BIT error as describe below. BIT byte13 Error <table> <tr> <th>Code</th><th>Description</th></tr> <tr> <td>0x01</td><td>Transmitter Shutdown</td></tr> <tr> <td>0x02</td><td>Transmitter Overcurrent</td></tr> <tr> <td>0x03</td><td>Transmitter Undercurrent</td></tr> <tr> <td>0x04</td><td>Transmitter Undervoltage</td></tr> <tr> <td>0x10</td><td>FIFO interrupt missed</td></tr> <tr> <td>0x11</td><td>FIFO ISR re-entry</td></tr> <tr> <td>0x21</td><td>Sensor start failure</td></tr> <tr> <td>0x22</td><td>temperature sensor failure</td></tr> <tr> <td>0x23</td><td>pressure sensor failure</td></tr> <tr> <td>0x24</td><td>tilt sensor failure</td></tr> <tr> <td>0x27</td><td>Bad Comms with sensor</td></tr> <tr> <td>0x28</td><td>Bad Comms with sensor</td></tr> <tr> <td>0x29</td><td>Sensor Cal Data checksum failure</td></tr> <tr> <td>0x2A</td><td>Sensor Stream Data Fault</td></tr> <tr> <td>0x30</td><td>Stuck UART</td></tr> <tr> <td>0x31</td><td>QUART Transmit timeout</td></tr> <tr> <td>0x32</td><td>QUART IRQ Stuck</td></tr> <tr> <td>0x33</td><td>QUART Buffer stuck</td></tr> <tr> <td>0x34</td><td>QUART IRQ Active</td></tr> <tr> <td>0x35</td><td>QUART cannot clear interrupt</td></tr> <tr> <td>0x50</td><td>RTC low battery</td></tr> <tr> <td>0x51</td><td>RTC time not set</td></tr> <tr> <td>0x60</td><td>Lost Nonvolatile pointers</td></tr> <tr> <td>0x61</td><td>Erase operation failed</td></tr> <tr> <td>0x62</td><td>Error writing from flash to buffer 1</td></tr> <tr> <td>0x63</td><td>Error writing from buffer 1 to flash</td></tr> <tr> <td>0x64</td><td>Timed out checking if page is erased</td></tr> <tr> <td>0x65</td><td>Bad return when checking page</td></tr> <tr> <td>0x66</td><td>Loop Recorder Slate Full</td></tr> <tr> <td>0x70</td><td>Unable to write to FRAM</td></tr> </table>	Code	Description	0x01	Transmitter Shutdown	0x02	Transmitter Overcurrent	0x03	Transmitter Undercurrent	0x04	Transmitter Undervoltage	0x10	FIFO interrupt missed	0x11	FIFO ISR re-entry	0x21	Sensor start failure	0x22	temperature sensor failure	0x23	pressure sensor failure	0x24	tilt sensor failure	0x27	Bad Comms with sensor	0x28	Bad Comms with sensor	0x29	Sensor Cal Data checksum failure	0x2A	Sensor Stream Data Fault	0x30	Stuck UART	0x31	QUART Transmit timeout	0x32	QUART IRQ Stuck	0x33	QUART Buffer stuck	0x34	QUART IRQ Active	0x35	QUART cannot clear interrupt	0x50	RTC low battery	0x51	RTC time not set	0x60	Lost Nonvolatile pointers	0x61	Erase operation failed	0x62	Error writing from flash to buffer 1	0x63	Error writing from buffer 1 to flash	0x64	Timed out checking if page is erased	0x65	Bad return when checking page	0x66	Loop Recorder Slate Full	0x70	Unable to write to FRAM
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0x31	QUART Transmit timeout																																																														
0x32	QUART IRQ Stuck																																																														
0x33	QUART Buffer stuck																																																														
0x34	QUART IRQ Active																																																														
0x35	QUART cannot clear interrupt																																																														
0x50	RTC low battery																																																														
0x51	RTC time not set																																																														
0x60	Lost Nonvolatile pointers																																																														
0x61	Erase operation failed																																																														
0x62	Error writing from flash to buffer 1																																																														
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0x66	Loop Recorder Slate Full																																																														
0x70	Unable to write to FRAM																																																														

Table 50: Pathfinder Output Data Format (PD6)

Line	Description
0x80	HEM data corrupt or not initialized.
0x81	HEM data corrupt or not initialized.
0x82	Failed to update HEM data.
0x83	Failed to update HEM data.
0x84	Failed to read HEM time data.
0x85	Failed to read HEM pressure data.
0x86	Failed to read HEM SPI state
0x87	Operating time over max.
0x88	Pressure reading over sensor limit.
0x89	Leak detected in sensor A.
0x8A	Leak detected in sensor B.
0xFF	Power failure
BIT Number of Errors byte 14	
Number of BIT errors	
If there is more than one BIT error, then it will take several ensembles to output all the BIT errors. For example, if there are 3 BIT errors detected, then the output will be BBB = 3xx on ensemble n, BBB = 3yy on ensemble n+1, and BBB = 3zz on ensemble n+2, where xx, yy, and zz are the three different error messages detected.	
3	WATER-MASS, INSTRUMENT-REFERENCED VELOCITY DATA :WI,±XXXXX,±YYYYY,±ZZZZZ,±EEEE,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) ±EEEE = 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,±EEEE,±NNNNN,±UUUUU,S <CR><LF> where: ±EEEE = 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)
6	WATER-MASS, EARTH-REFERENCED DISTANCE DATA :WD,±EEEEEEE.EE,±NNNNNNNN.NN,±UUUUUUUU.UU,DDDD.DD,TTT.TT <CR><LF> where: +EEEEEEE.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

Table 50: Pathfinder Output Data Format (PD6)

Line	Description
7	BOTTOM-TRACK, INSTRUMENT-REFERENCED VELOCITY DATA :BI,±XXXXX,±YYYYY,±ZZZZZ,±EEEE,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) ±EEEE = 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,±EEEE,±NNNNN,±UUUUU,S <CR><LF> where: ±EEEE = 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,±EEEEEEE.EE,±NNNNNNNN.NN,±UUUUUUUU.UU,DDDD.DD,TTT.TT <CR><LF> where: +EEEEEEE.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
11	SYSTEM HEALTH MONITOR DATA :HM,A,B,AAAA,BBBB,VV.VVV,C.CCC,RR.RRR<CR><LF> where: A = Status of leak sensor A ("G" = Good, "L" = Leak detected, "D" = Disconnect) B = Status of leak sensor B ("G" = Good, "L" = Leak detected, "D" = Disconnect) AAAA = Leak sensor A raw A/D reading, as four hexadecimal digits BBBB = Leak sensor B raw A/D reading, as four hexadecimal digits VV.VVV = Transmit voltage, in volts C.CCC = Transmit current, in amperes RR.RRR = transducer impedance, in ohms. (The voltage and current readings are omitted if they are not available) (The transducer resistance reading is omitted if either the voltage or current readings are not available.) (The transducer resistance reading will saturate at 65.535 ohms, i.e. any resistance higher than that will still be reported as 65.535 ohms.)

The PD6 output does not pad spaces with zeroes. The spaces are left intact. The example below shows a realistic output from a Pathfinder locked onto the bottom and the values of the System Health Monitor Data is shown in red.

```
:SA, -2.31, +1.92, 75.20
:TS,04081111563644,35.0,+21.0, 0.0,1524.0, 0
:WI,-32768,-32768,-32768,-32768,V
:WS,-32768,-32768,-32768,V
:WE,-32768,-32768,-32768,V
:WD, +0.00, +0.00, +0.00, 20.00, 0.00
:BI, +24, -6, -20, -4,A
:BS, -13, +21, -20,A
:BE, +17, +18, -20,A
:BD, -0.02, -0.03, +0.02, 7.13, 0.21
:HM,G,G,0C8E,0B2E,33.214,1.215,27.337<CR><LF> ➔ 33.214 Volts, 1.215 amps, 27.337 ohms
```

Pathfinder NMEA Output (PD11)

The Pathfinder sends this data format only when the PD11 command is used. Data will continue to be recorded to the internal recorder in PDO 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.



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.

[illegible]

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>
```

Pathfinder Output Data Format (PD13)

The Pathfinder sends this data format only when the PD13 command is used. The DVL outputs data in the following line order. The DVL may not send 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 51. Pathfinder 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,YMMDDHHmmsshh,SS.S,±TT.T,DDDD.D,CCCC.C,BBB <CR><LF> where: YMMDDHHmmsshh = 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 where the first B on the left is the number of BIT errors (MSB) and the last 2 BB (LSB) are the actual BIT error as describe below. BIT byte13 Error <table> <tr> <th>Code</th><th>Description</th></tr> <tr> <td>0x01</td><td>Transmitter Shutdown</td></tr> <tr> <td>0x02</td><td>Transmitter Overcurrent</td></tr> <tr> <td>0x03</td><td>Transmitter Undercurrent</td></tr> <tr> <td>0x04</td><td>Transmitter Undervoltage</td></tr> <tr> <td>0x10</td><td>FIFO interrupt missed</td></tr> <tr> <td>0x11</td><td>FIFO ISR re-entry</td></tr> <tr> <td>0x21</td><td>Sensor start failure</td></tr> <tr> <td>0x22</td><td>temperature sensor failure</td></tr> <tr> <td>0x23</td><td>pressure sensor failure</td></tr> <tr> <td>0x24</td><td>tilt sensor failure</td></tr> <tr> <td>0x27</td><td>Bad Comms with sensor</td></tr> <tr> <td>0x28</td><td>Bad Comms with sensor</td></tr> <tr> <td>0x29</td><td>Sensor Cal Data checksum failure</td></tr> <tr> <td>0x2A</td><td>Sensor Stream Data Fault</td></tr> <tr> <td>0x30</td><td>Stuck UART</td></tr> <tr> <td>0x31</td><td>QUART Transmit timeout</td></tr> <tr> <td>0x32</td><td>QUART IRQ Stuck</td></tr> <tr> <td>0x33</td><td>QUART Buffer stuck</td></tr> <tr> <td>0x34</td><td>QUART IRQ Active</td></tr> <tr> <td>0x35</td><td>QUART cannot clear interrupt</td></tr> <tr> <td>0x50</td><td>RTC low battery</td></tr> <tr> <td>0x51</td><td>RTC time not set</td></tr> <tr> <td>0x60</td><td>Lost Nonvolatile pointers</td></tr> <tr> <td>0x61</td><td>Erase operation failed</td></tr> <tr> <td>0x62</td><td>Error writing from flash to buffer 1</td></tr> <tr> <td>0x63</td><td>Error writing from buffer 1 to flash</td></tr> <tr> <td>0x64</td><td>Timed out checking if page is erased</td></tr> <tr> <td>0x65</td><td>Bad return when checking page</td></tr> <tr> <td>0x66</td><td>Loop Recorder Slate Full</td></tr> <tr> <td>0x70</td><td>Unable to write to FRAM</td></tr> </table>	Code	Description	0x01	Transmitter Shutdown	0x02	Transmitter Overcurrent	0x03	Transmitter Undercurrent	0x04	Transmitter Undervoltage	0x10	FIFO interrupt missed	0x11	FIFO ISR re-entry	0x21	Sensor start failure	0x22	temperature sensor failure	0x23	pressure sensor failure	0x24	tilt sensor failure	0x27	Bad Comms with sensor	0x28	Bad Comms with sensor	0x29	Sensor Cal Data checksum failure	0x2A	Sensor Stream Data Fault	0x30	Stuck UART	0x31	QUART Transmit timeout	0x32	QUART IRQ Stuck	0x33	QUART Buffer stuck	0x34	QUART IRQ Active	0x35	QUART cannot clear interrupt	0x50	RTC low battery	0x51	RTC time not set	0x60	Lost Nonvolatile pointers	0x61	Erase operation failed	0x62	Error writing from flash to buffer 1	0x63	Error writing from buffer 1 to flash	0x64	Timed out checking if page is erased	0x65	Bad return when checking page	0x66	Loop Recorder Slate Full	0x70	Unable to write to FRAM
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0x66	Loop Recorder Slate Full																																																														
0x70	Unable to write to FRAM																																																														

Table 51. Pathfinder Output Data Format (PD13)

Line	Description
0x80	HEM data corrupt or not initialized.
0x81	HEM data corrupt or not initialized.
0x82	Failed to update HEM data.
0x83	Failed to update HEM data.
0x84	Failed to read HEM time data.
0x85	Failed to read HEM pressure data.
0x86	Failed to read HEM SPI state
0x87	Operating time over max.
0x88	Pressure reading over sensor limit.
0x89	Leak detected in sensor A.
0x8A	Leak detected in sensor B.
0xFF	Power failure
BIT Number of Errors byte 14	
Number of BIT errors	
If there is more than one BIT error, then it will take several ensembles to output all the BIT errors. For example, if there are 3 BIT errors detected, then the output will be BBB = 3xx on ensemble n, BBB = 3yy on ensemble n+1, and BBB = 3zz on ensemble n+2, where xx, yy, and zz are the three different error messages detected.	
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,±ZZZZ,±EEEE,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) ±ZZZZ = Z-axis vel. data in mm/s (+ = transducer movement away from water mass) ±EEEE = Error velocity data in mm/s S = Status of velocity data (A = good, V = bad)
5	WATER-MASS, SHIP-REFERENCED VELOCITY DATA :WS,±TTTT,±LLLL,±NNNNN,S <CR><LF> where: ±TTTT = Transverse vel. data in mm/s (+ = Port Stbd ship movement rel. to water mass) ±LLLL = 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)
6	WATER-MASS, EARTH-REFERENCED VELOCITY DATA :WE,±EEEE,±NNNNN,±UUUUU,S <CR><LF> where: ±EEEE = 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 51. Pathfinder Output Data Format (PD13)

Line	Description
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,±EEEE,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) ±EEEE = 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,±EEEE,±NNNNN,±UUUUU,S <CR><LF> where: ±EEEE = 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

The PD13 output does not pad spaces with zeroes. The spaces are left intact. The example below shows a realistic output from a Pathfinder locked onto the bottom.

```
:SA, -2.31, +1.92, 75.20
:TS,04081111563644,35.0,+21.0, 0.0,1524.0, 0
:RA, 0.00, 71.31, 71.32, 71.32, 71.31
:WI,-32768,-32768,-32768,-32768,V
:WS,-32768,-32768,-32768,V
:WE,-32768,-32768,-32768,V
:WD, +0.00, +0.00, +0.00, 20.00, 0.00
:BI, +24, -6, -20, -4,A
:BS, -13, +21, -20,A
:BE, +17, +18, -20,A
:BD, -0.02, -0.03, +0.02, 7.13, 0.21
```

Pathfinder Speed Log Format (PD26)

The Pathfinder provides the ability to output the PD26 data type over the serial interface with the PD command or using the HTML interface.

\$VMVBW – Dual Ground/Water Speed

Format:

```
$VMVBW,x.xx,x.xx,A,x.xx,x.xx,A,x.xx,A,x.xx,A*hh<CR><LF>
      1    2    3 4    5    6 7    8 9    10
```

Where:

- 1 = Longitudinal water speed, knots
- 2 = Transverse water speed, knots
- 3 = Status, water speed: A=Valid, V=Invalid
- 4 = Longitudinal ground speed, knots
- 5 = Transverse ground speed, knots
- 6 = Status, ground speed: A=Valid, V=Invalid
- 7 = Stern transverse water speed, knots
- 8 = Status, stern water speed: A=Valid, V=Invalid
- 9 = Stern transverse ground speed, knots
- 10 = Status, stern ground speed: A=Valid, V=Invalid

Notes:

- The \$VMVBW longitudinal ground speeds is determined from the forward component of the ship frame bottom track velocity vector.
- The sign of the \$VMVBW longitudinal speeds is positive for forward motion of the ship relative to the bottom in the ship frame. Note that this is identical to the PD6 transverse sign convention.
- The \$VMVBW transverse ground speeds is produced from the starboard component of the ship frame velocity vector.
- The sign of the \$VMVBW transverse ground speeds is positive for motion of the ship in the starboard direction relative to the bottom in the ship frame. Note that this is identical to the PD6 transverse speed sign convention.
- The \$VMVBW ground speeds is corrected for pitch and roll.

- The pitch and roll parameters for \$VMVBW ground velocities is sourced per the EZ configuration.
- The status of \$VMVBW ground speeds is determined from the validity of a 3 or 4 beam bottom velocities; 0, 1, or 2 valid beams shall equate to invalid.
- The sign of the \$VMVBW transverse ground speeds is positive for motion of the ship in the starboard direction relative to the bottom in the ship frame. Note that this is identical to the PD6 transverse speed sign convention.
- The \$VMVBW ground speeds is corrected for pitch and roll.
- The pitch and roll parameters for \$VMVBW ground velocities is sourced per the EZ command configuration.
- The status of \$VMVBW ground speeds is determined from the validity of a 3 or 4 beam bottom velocities; 0, 1, or 2 valid beams shall equate to invalid.

\$VMDBT – Depth Below Transducer

Format:

```
$VMDBT, x.x, f, x.x, M, x.x, F*hh<CR><LF>
      1   2 3   4 5   6 7
```

Where:

1 = Depth, feet

2 = f = feet

3 = Depth, meters

4 = M = meters

5 = Depth, Fathoms

6 = F = Fathoms

7 = Checksum

Notes:

- The \$VMDBT depth is determined from the mean of the vertical range-to-bottom of each valid beam from the bottom track ping. Note this is equivalent to the PD6 BD range to bottom field.

\$VMVLW – Distance Traveled through Water

Format:

```
$VMVLW, x.x, N, x.x, N*hh<CR><LF>
      1   2 3   4 5
```

Where:

1 = Total cumulative distance

2 = N = Nautical Miles

3 = Distance since Reset

4 = N = Nautical Miles

5 = Checksum

Notes:

- The cumulative distance is calculated for each ensemble as follows:

$$LEast = 1 / 2 * (VEast[n - 1] + VEast[n]) * (T[n] - T[n - 1]) \quad (1)$$

$$LNorth = 1 / 2 * (VNorth[n - 1] + VNorth[n]) * (T[n] - T[n - 1]) \quad (2)$$

$$Length = Length + \sqrt{LEast^2 + LNorth^2} \quad (3)$$

Where:

L = length
 V = velocity

n = the ensemble number
 T = time

- The \$VMVLW cumulative distance is calculated from the bottom track earth referenced velocity data.
- The \$VMVLW cumulative distance will clear:
 - Upon ping initiation from CS command
 - Upon reception of a hardware or software break
 - Upon ping initiation from turnkey mode start
 - Upon receipt of a 'dynamic' BS or #BS command from serial or Ethernet port
- The \$VMVLW distance since reset shall clear upon application of power to the Pathfinder (cold boot).

Decoding a Pathfinder Ensemble

Use the following information to help write software.

Rules for the BroadBand Data Format PDO

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 52: 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

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 3.
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 Pathfinder. If additional sensor data is to be added to the variable leader data then it must be added to the end of the data string (bytes 54-x as an example).
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.

Decoding Sequence for PD0 Data

1. Locate the header data by locating the header ID number (in the case of PD0 profile data that will be 7F7F).
2. Confirm the correct header ID by:
 - a. Locate the checksum offset (located in the header data). This is the offset to the checksum word in the current ensemble. The size of the ensemble is this offset plus 2 bytes (to account for the checksum word), which is also the 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 calculated 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 then this is a valid ensemble. If the checksums do not match then it is not a valid ensemble and should 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 to decode by using the offset to each data type and confirm the data ID number at that offset matches the ID type looking for.
6. Once the proper ID type has been located, use the Pathfinder Technical Manual to understand what each byte represents in that particular data type.

NOTES

Appendix **A**

NOTICE OF COMPLIANCE



In this chapter, you will learn:

- China RoHS requirements
- Material disclosure table

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 53.

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 the unit 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 53. 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
换能器接口电路板 Transducer Intfc PCB	O	O	O	O	O	O
底座装配 End-Cap Assy.	X	O	O	O	O	O
接收机电路板 Receiver PCB	O	O	O	O	O	O
数据处理器电路板 DSP PCB	O	O	O	O	O	O
输入输出接口电路板 PIO PCB	O	O	O	O	O	O
通讯接口板 Personality Module	O	O	O	O	O	O
外接电缆 External Cables	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

Appendix **B**

MATLAB OUTPUT



In this chapter, you will learn:

- Matlab Output Variable Definitions

Matlab Output Variable Definitions

The following includes a basic definition of the Matlab output variable definitions from *WinADCP*. If further clarification is needed please contact TRDI Field Service.

AnBIT - Built in test

AnBATT - Battery level

AnDepthmm -Depth in mm

AnH100thDeg - Heading to 1/100th of a degree

AnOrienUP - Up/down orientation

AnP100thDeg - Pitch rotation to 1/100th of a degree

AnR100thDeg - Roll rotation to 1/100th of a degree

AnT100thDeg - Yaw rotation to 1/100th of a degree

RDIBin1Mid - Distance to middle of Bin 1

RDIBinSize - Bin Size

RDIEnsDate - Ensemble start date

RDIEnsInterval - Ensemble Interval

RDIEnsTime - Time per Ensemble (te command)

RDIFileName - File name and directory

RDIPingsPerEns - Pings per ensemble (wp command)

RDISecPerPing - time per ping (tp command)

RDISystem - type of system

SerBins - bin association

SerC1cnt - Beam 1 correlation

SerC2cnt - Beam 2 correlation

SerC3cnt - Beam 3 correlation

SerC4cnt - Beam 4 correlation

SerDay - day (time)

SerDir10thDeg - Heading to 1/10th of a degree

SerEA1cnt - Echo Amplitude beam 1

SerEA2cnt - Echo Amplitude beam 2

SerEA3cnt - Echo Amplitude beam 3

SerEA4cnt - Echo Amplitude beam 4

SerEnsembles - Number of ensembles

SerErmmpersec - Error velocity in mm/s

SerHour - Hour (time)

SerHund - Hundredths of a second (time)

SerMagmmpersec - Magnitude in mm/s

SerMin - Minute (time)

SerMon - Month (time)

SerPG1 - Percent good beam 1

SerPG2 - Percent good beam 2

SerPG3 - Percent good beam 3

SerPG4 - Percent good beam 4

SerSec - Seconds (time)

SerVmmpersec - Velocity in mm/s

SerYear - Year (time)

NOTES