WORKHORSE II

MONITOR, SENTINEL, & MARINER

OPERATION MANUAL

P/N 957-6298-00 (April 2024)

https://www.teledynemarine.com

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Revision History

April 2024

- Updated 967-6164 outline installation drawing.

March 2024

- Changed Velocity Accuracy Table 25, page 134 for 1200 and 600kHz from 0.25% and ±2.5 mm/s to 0.3% and ± 3mm/s.

February 2024

- Updated Returning Systems to the TRDI Factory, page 127 Brokerage address.

January 2024

- Updated outline installation drawing 967-6162 for external battery.

December 2023

- Added outline installation drawing 967-6164 for Mariner.

October 2023

- Updated Figure 10 and Figure 24.
- Updated Figure 21 signal names.

September 2023

- Updated battery installation procedure. Added photos.

August 2023

- Added required tools to open and close the housing.
- Updated computer requirements.

July 2023

- Updated website address.
- Updated outline drawings 967-6160 and 967-6161.

June 2023

- Corrected signal names on Figure 23. Mariner I/O Cable Wiring 737-3177-XXX.

April 2023

- Updated transducer beam color to red.
- Updated recorder capacity.

December 2022

- Updated EAR statement.
- Updated transducer beam color to black.

November 2022

- Initial release.

How to Contact Teledyne RD Instruments

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

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Self-Service Customer Portal

Use our online customer portal at https://www.teledynemarine.com/support/RDI/technical-manuals to download manuals or other Teledyne RDI documentation.

Teledyne Marine Software Portal

Teledyne RD Instruments Firmware, software, and Field Service Bulletins can be accessed only via our Teledyne Marine software portal.

To register, please go to https://tm-portal.force.com/TMsoftwareportal 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, use the Teledyne Marine software portal to access this data with your unique username and password.

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

CONVENTIONS USED IN THIS MANUAL

Conventions used in the Workhorse II Acoustic Doppler Current Profiler (ADCP) Operation Manual have been established to help learn how to use the system quickly and easily.

Menu items are printed in bold: click **File**, **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.txt*).

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

```
[BREAK Wakeup A]
Workhorse II Broadband ADCP Version 77.xx
Teledyne RD Instruments (c) 1996-2021
All Rights Reserved.
>
```

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

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

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

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

Chapter 1

OVERVIEW

This chapter covers:

- Workhorse II Models and Options
- System Overview
- Computer Considerations
- Power Overview
- Setting up the ADCP
- Caring for your Workhorse II System

System Overview

The Workhorse II ADCP transducer assembly contains the end-cap, housing, transducer ceramics, and electronics. The standard acoustic frequencies are 1200, 600, and 300 kHz. See the Outline Installation Drawings for dimensions and weights.

Picture	Description
	The cable connects the Workhorse II ADCP to the computer and external power supply. When the cable is not connected, use the dummy plug to protect the connector.
	The end-cap holds the Impulse MCIL-8-FS connector. When assembling the unit, match the Beam 3 mark on the end-cap with beam 3 number on the transducer. The Vent plug provides a way for internal pressure to escape once the plug is backed out and is no longer sealed yet the threads remain engaged. This is important in cases where there's a concern about the plug becoming a projectile should there be internal pressure inside the housing.
	The Beam-3 mark shows the location of Beam-3 (Forward).
	The Thermistor measures the water temperature.
	The pressure sensor (standard 20 Bar, 200m) measures water pressure (depth).
	The urethane faces cover the transducer ceramics. Never set the transducer on a hard surface. The urethane faces may be damaged.
	The standard Workhorse II white plastic housing allows deployment depths to 200 meters.
	The Workhorse II electronics and transducer ceramics are mounted to the transducer head. The numbers embossed on the edge of the transducer indicate the beam number. When assembling the unit, match the transducer beam number 3 with the Beam 3 mark on the end-cap.
	The Sentinel ADCP includes a longer housing to hold a battery. The internal alkaline battery pack has 450 watt-hours (Wh) of usable energy at 0 C. Lithium batteries have a capacity of approximately 1650 Wh.
	Workhorse II Sentinel ADCPs come standard with one Delkin C600 series CompactFlash memory card with the maximum memory capacity not to exceed 4GB per deployment.

Workhorse II Models and Options

The following section explains the different models and options available for Workhorse II ADCPs.

Workhorse II Monitor

The Workhorse II Monitor is designed to measure real-time current profiles from temporary or permanent mounting in the ocean, near-shore, harbors, and lakes. The Monitor ADCP system consists of an ADCP, pigtail cable, CompactFlash (CF) memory card, and software. The Monitor system requires the addition of a Windows® compatible computer to collect data.

Figure 1. Workhorse II Monitor ADCP

Workhorse II Sentinel

The Workhorse II Sentinel is designed for several-month autonomous current profile deployment from temporary or permanent mounting in the ocean, near-shore, harbors, and lakes. The Sentinel ADCP system consists of an ADCP, cables, battery pack, CompactFlash (CF) memory card, and software. The battery capacity can be increased with upgrades for longer deployments. The Sentinel can also be used for direct-reading current profile operation. The Sentinel system requires the addition of a Windows® compatible computer to configure the ADCP and replay collected data.

Figure 2. Workhorse II Sentinel ADCP

Workhorse II Mariner

The Workhorse II Mariner is designed to measure real-time current profiles from temporary or permanent mounting in a vessel. The Mariner ADCP system consists of a Monitor ADCP with Bottom Track mode, cables, Deck Box, Mounting Plate, CompactFlash (CF) memory card, and software.

The Deck Box converts AC power input or 12 VDC input into 48 VDC output for the Mariner input power. It can convert the computer serial interface from RS232 to RS422. The Mariner system requires the addition of a Windows® compatible computer to collect data.

Figure 3. Workhorse II Mariner ADCP

Workhorse II Options

- **Conversion Cable** – Converts from the new 8-pin circular Impulse MCIL-8-FS connector to the flat 7-pin Impulse LPMIL-7-FS connector. Use this cable to connect the Workhorse II to an existing cable installation.
- **Bottom Track** – You can use your Workhorse II ADCP from moving boats and ships with the Bottom Track upgrade. Once the Bottom Track upgrade is added, a Workhorse II ADCP can measure both water depth and boat velocity over the ground.
- **Shallow Water Bottom Track Mode 7** – You can use your Workhorse II 1200 kHz ADCP in water as shallow as 30cm. This firmware feature is included with all 1200 kHz Workhorse II ADCPs (requires Bottom Track option enabled).
- **High-Resolution Water Profiling Modes** – This firmware feature allows you to collect water profiles using Water Modes 1 (default) and 11. This firmware feature is included with all Workhorse II ADCPs.
- **High Ping Rate Water Mode** – This firmware feature allows you to collect water profiles using Water Mode 12. This firmware feature is included with all Workhorse II ADCPs.

Water Modes 11 and 12 were designed for 600 and 1200 kHz ADCPs. Using these modes on 300 kHz ADCPs is not recommended.

- **Waves** – This upgrade allows you to use the ADCP as a wave gauge.
- **Lowered ADCP** – This upgrade enables the Water Mode 15 Lowered ADCP mode. WM15 is also used for Surface Tracking to track boundary layers such as the air/sea surface or the bottom of an ice layer.

For more information on LADCP deployments and WM15, see the LADCP User's Guide.

- **VmDas Software** – TRDI software to controls the ADCP and displays profile data through a personal computer.
- **WinRiver II Software** – TRDI software to control the ADCP and displays discharge data and profile data through a personal computer.
- **Waves Software** – TRDI software to control the ADCP and displays waves data through a personal computer.
- **Velocity Software** – *Velocity* gives the user a visual sense of data. It also allows the user to zoom in on a portion of the data for closer analysis.
- **Memory** – The Workhorse II Sentinel ADCP includes one CompactFlash card which can store up to 4GB of data per deployment.
- **Spare boards kit** – Contains a complete set of spare printed circuit boards for a Workhorse II ADCP. The set does not include the receiver board (not field replaceable).
- **High-Pressure Housing** – The standard Workhorse II housing allows deployment depths to 200 meters. High-pressure housings are available with depth rating of 6000 meters (future release).
- **External Battery** – Adding an external battery can increase the deployment length for Sentinel ADCPs. Use an External Battery with a Monitor ADCP to provide backup power or for self-contained deployments.

Figure 4. Workhorse II External Battery Case Overview

- **Lithium Battery Pack** – The optional Workhorse II Lithium Battery Packs can be used interchangeably in Workhorse II Sentinels and the external battery case. This battery pack is assembled using lithium battery cells that provide 34 VDC with a capacity of approximately 1650 Wh. The battery includes a safety circuit that protects the battery and users against short circuits and provides users the ability to test the pack. The circuit also turns the battery off at its end of life before the battery fully discharges. This happens when about 97% of the battery's capacity is depleted.

Mariner Options

- **Mounting Plate** – A bronze plate that helps mount the transducer head to a vessel. See the Outline Installation Drawings for dimensions.

Mariner Deck Box Overview

The deck Box contains all interfaces to/from the ADCP, computer/terminal, and power.

Power Switch – The power switch is a combination switch/circuit breaker. The **Power Status** LED next to the circuit breaker lights when power is applied to the Deck Box.

Reset Button – Pushing the **Reset** button sends a break to the ADCP.

Data In/Out LEDs – **Channel 1 In** indicates data transmission from the computer to the ADCP. **Channel 1 Out** indicates data transmission from the ADCP to the computer.

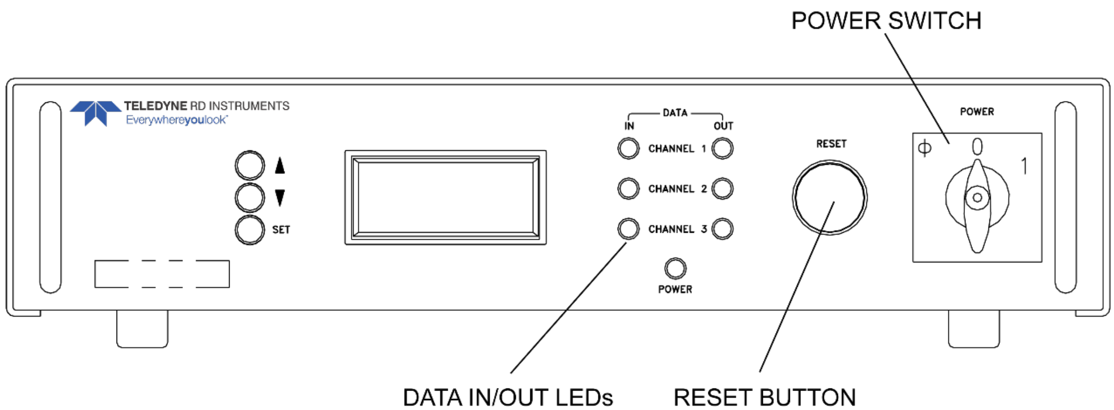


Figure 5. Deck Box (Front View)

ADCP (J17) – Connects the ADCP to the deck box.

Channel 1 RS 422 (J19) – Connects the computer's RS-422 port to the deck box. Use this only if your computer has a RS422 serial port. If your computer has a RS-232 serial port (standard), use J20.

Channel 1 RS 232 (J20) – Connects the computer RS-232 port to the deck box.

AC Power Input – The deck box accepts input voltages of 98-264 VAC, 50-60Hz (J27). This input voltage will be converted to 48 VDC. This is the voltage supplied to the ADCP.

DC 12-Volt Input – Use a 12 VDC car battery (J26) when AC power is not available. The deck box converts the voltage to 48 VDC. This is the voltage supplied to the ADCP. Use the largest rated amp-hour battery as possible. A car battery can power a 1200 kHz ADCP for approximately one to two days.

DC 20 to 50 Volt Input – If you are using an external DC power supply connected to the deck box on J25 (20 to 50 VDC, 3.0 A), the voltage from the external power supply is sent *directly* to the ADCP. This is useful if you want to increase (higher voltage level) or decrease (lower voltage level) the range of the ADCP. The current requirement for the power supply is listed as a reference. Using a lesser-rated power supply can cause the voltage level to drop. The ADCP will draw only the current it needs.

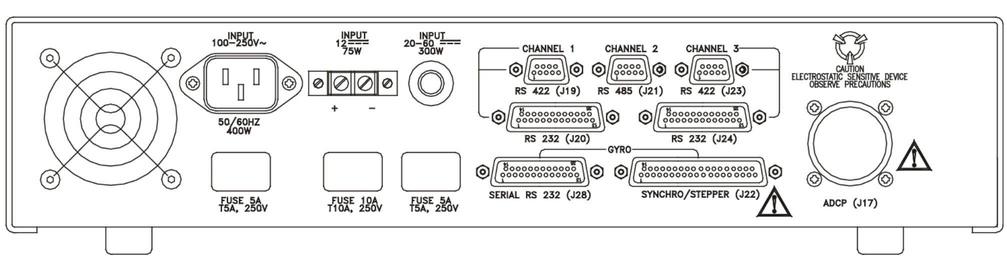


Figure 6. Deck Box (Rear View)

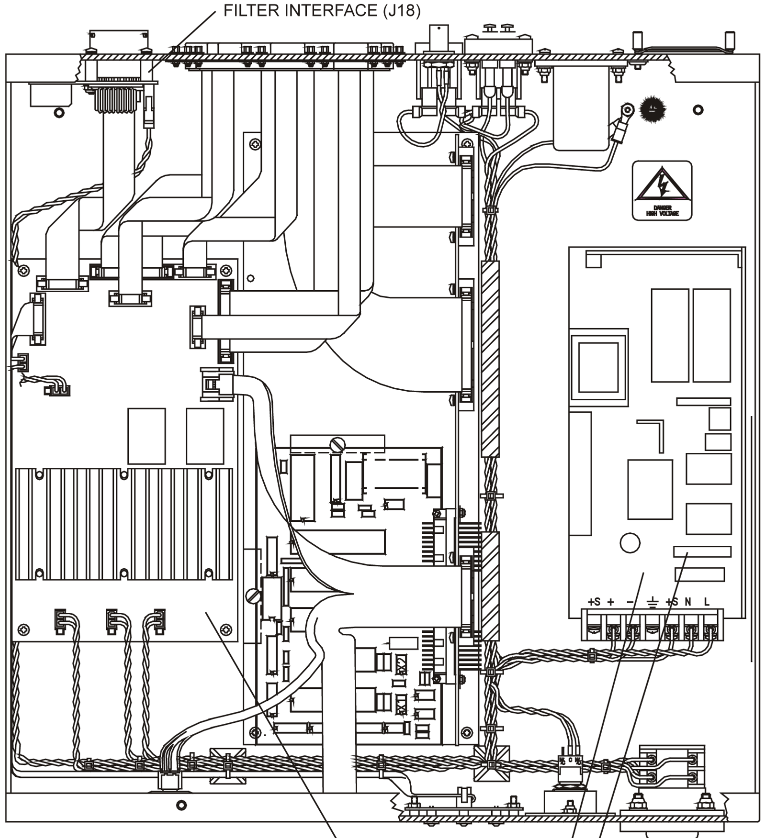


Figure 7. Deck Box (Top View)

Mariner Triggering Function

In some applications, it is advantageous to have the ability to trigger the transmit cycle of the WorkHorse Mariner ADCP. Triggering the WorkHorse Mariner ADCP allows you to synchronize the time when it transmits with other devices to avoid interference between the acoustic instruments.

The standard WorkHorse Mariner Deckbox is designed to work with a WorkHorse Mariner ADCP down long cables using RS-422 communications. If triggering is desired, then the WorkHorse Mariner Deckbox must be modified from its standard RS-422 communications link to the Mariner ADCP to a RS-232 communications link.

This modification must be done (or ordered for new systems) at Teledyne RD Instruments factory and requires the return of the WorkHorse Mariner Deckbox and the WorkHorse Mariner ADCP.

Please contact your local sales representative if you are interested in modifying your system for this feature.

All communications and other functions described in the WorkHorse Operation Manual and Mariner Deployment Guide are correct and apply to the Mariner system.

Using the Modified Deckbox with Trigger

The following procedure assumes you have a modified WorkHorse Mariner Deckbox, and the Mariner ADCP is set to RS-232 communications. The front of your Mariner Deckbox will be clearly marked indicating that it has Trigger.

Communication Setup

The standard communications setup to the WorkHorse Mariner Deckbox with Trigger remains the same as with a standard WorkHorse Mariner Deckbox. The only difference is that the WorkHorse Mariner Deckbox with Trigger has been permanently changed to only pass-through RS-232 communications down to the ADCP. As a result of this modification, the WorkHorse Mariner ADCP must be set to RS-232 communications. This setting is controlled via a switch inside the ADCP and will have been set by TRDI during the modification of your Deckbox if ordered for a new system.

See Changing Communications Setting for more information.

Communications to the WorkHorse Mariner ADCP is through the RS-232 25-pin connector J20 on the back of the Deckbox. Connect the computer to this connector to establish communications to the Mariner ADCP.

For reliable communications, the RS-232 cable to Deckbox must be less than 25-meters length and the J17 cable to the Mariner must be no longer than 25-meters.

Baud Rate Setup Considerations

The default baud rate of the WorkHorse Mariner is 9600. The maximum baud rate possible when using the WorkHorse Mariner Deckbox with Trigger is 38400. Triggering only works with a baud-rate less than 38400.

Trigger Signals, Breaks, and Commands

The Mariner ADCP Deckbox can only be set up in slave mode (receiving trigger signals from other instruments). The setup is controlled through the Ping Synchronization Commands (**SA**, **SM**, **ST**, and **SW**). The default setup for the Workhorse Mariner is for triggering to be disabled (**SM0**). The **SB** command must be set to **SB0** to use the Master/Slave setup.

To avoid a trigger-signal being handled as a hardware-break, the **SB0** command needs to be set.

To set the SB command to SB0:

1. Send **SB0**.
2. Immediately following the **SB0** command, send a **Break**.
3. The **SB0** command is now in effect and the ADCP will ignore potential <Breaks> on the Channel B RS-422 lines.

Once the SB0 command is set, it will not be reset by a CR1 command (SB1 is the default setting).

4. To enable the triggering in the slave mode, add the following commands to the command file used for the Workhorse Mariner.

```
SM2
ST0
WP1
TE00:00:00.00
TP000000
```

Injecting a Trigger Signal

The access to the trigger is via the DB9 connector labeled J21 RS485 on the back of the Deckbox. Pin 6 is (+) and pin 5 is (GND). The input trigger pulse must be a TTL pulse between 15mSec to 38mSec.

The WorkHorse Mariner only allows a Trigger In signal.

Verify Triggering on The Bench

Before installing the system in the field, verify it on the bench.

1. Connect the Workhorse Mariner to the Mariner Deckbox.
2. Apply power to the Mariner Deckbox.
3. Connect a serial cable from the Deckbox to a PC and open *TRDI Toolz*.
4. Use a frequency generator to generate a TTL pulse width of 20mSec every second.
5. In *TRDI Toolz* send following commands:

```
CR1
WP1
TE00:00:00.00
TP000000
SM2
ST0
CK
CS
```

The Mariner should now ping every second.

Computer Considerations

TRDI designed the Workhorse II ADCP to use a Windows® compatible computer. The computer controls the ADCP and displays its data, usually through our *Velocity*, *VmDas,* or *WinRiver II* programs. For testing, TRDI provides *TRDI Toolz* and for system configuration for deployments, use *Workhorse II Plan*.

> TRDI highly recommends downloading and install all the critical updates, recommended updates, and the service releases for the version of Windows® that you are using prior to installing any TRDI software.

Minimum Computer Hardware Requirements:

- Windows 11® or Windows 10® Desktop, Laptop, or Netbook computer
- Screen resolution above 1024x768
- One Serial Port (two or more High Speed UART Serial Port recommended)

> *VmDas* has special requirements – see the VmDas User's Guide for detailed information on system requirements.

Workhorse II Software

The Workhorse II requires *TRDI Toolz*, *Workhorse II Plan*, *ISM Compass Calibration,* and *Compass Post Calibration* software.

To download the software:

1. Use the Teledyne Marine software portal https://tm-portal.force.com/TMsoftwareportal to access the software.
2. Download the *TRDI Toolz*, *Workhorse II Plan, ISM Compass Calibration*, and *Compass Post Calibration* software.
3. Unzip the files and install by double-clicking on the exe files.

Power Overview

Workhorse II Monitor, Sentinel, and Mariner ADCPs require +20 to 50 VDC to operate.

Monitor/Sentinel Power Considerations

The AC Adapter runs on any standard AC power and supplies +48 VDC to run the Workhorse II when the batteries are not connected. The Sentinel's internal battery supplies +42 VDC.

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

Transmitted power increases or decreases depending on the input voltage (within the voltage range of 20 to 50 VDC). A fresh battery provides +42 VDC. Batteries spend most of their life at a nominal voltage of +33 VDC.

> The transmitted power is decreased approximately 1 DB if the input voltage drops from 42 VDC to 33 VDC. For a 300 kHz Workhorse II ADCP, each DB will result in a decrease in range of one default depth cell.

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 ADCP. The capacitors provide a store of energy for use during transmit. The inrush current is as high as 3 Amps rms. The ADCP will draw this amperage until its capacitors are fully charged.

If the power supply limits the current or the power drop on the cable is significant, then the power on cycle will take longer. It can take up to one minute. You do not want the power to shut down during the inrush current draw, as this may not allow the ADCP electronics to start.

AC Power Adapter

The optional AC power adapter is designed to maintain a 400-ma supply under the ADCP's inrush current. The adapters are 100-Watt supplies, with 48 VDC, 1.8-amp outputs. They will not fall back to 0 amps, 0 volts under a load. Customer provided power supplies might shut themselves down under such a load; when that occurs, the ADCP will not wakeup.

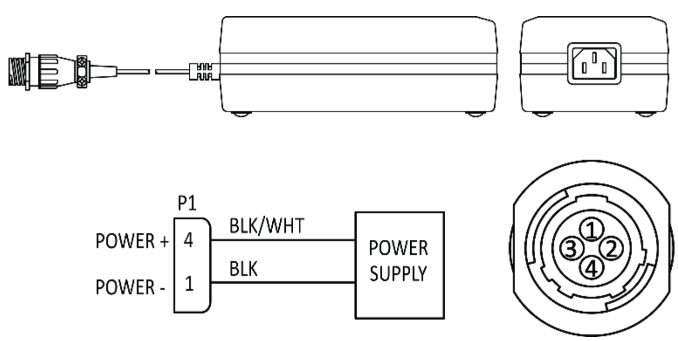


Figure 8. AC Power Adapter

Sentinel Internal Battery Power Overview

The Workhorse II Sentinel's internal battery supplies +42 VDC. The AC Adapter runs on any standard AC power and supplies +48 VDC to run the Workhorse II Sentinel when the batteries are not connected.

The AC Adapter input voltage is sufficient to override the internal battery voltage (for example, the ADCP will draw all power from the AC adapter even if the battery is installed and connected). Always use the AC adapter when testing the ADCP to conserve the battery power.

Keep in mind the following about Sentinel Alkaline battery packs:

- TRDI specifies its battery packs to have 450 Watt-hours (Wh) of usable energy at 0°C.
- A Standard Workhorse II battery packs hold 28 'D-cell' alkaline batteries with a voltage, when new, of approximately 42 VDC.
- When the capacity of a battery pack is 50% used, the voltage (measured across the battery connector) falls to approximately 32 to 35 volts. However, keep in mind that this voltage is not an accurate predictor of remaining capacity.
- Transmitted power increases or decreases depending on the input voltage (within the voltage range of 20 to 50 VDC). A fresh battery provides +42 VDC. Batteries spend most of their life at a nominal voltage of +33 VDC.

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

- Batteries should be replaced when the voltage falls below 30 VDC (measured across the battery connector).
- Battery packs differ from one to another.
- Store batteries in a cool dry location (0 to 21 degrees C).
- Do not store batteries inside the ADCP for extended periods. The batteries may leak.
- Use batteries within one year of the manufacture date (use by warning date*).

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

TRDI batteries have four dates on them:

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

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

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

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

*A battery pack used to start a deployment prior to the Warning Date means that it will perform as expected and provide the required power for any deployment that was created using the TRDI planning module. For example, if your deployment is going to be 12 months long and the battery label shows it is nine months old, it is safe to use the battery.

Battery replacement induces both single and double cycle compass errors. The compass should be calibrated after replacing the battery pack.

These compass effects can be avoided by using an optional external battery pack. The optional external battery housing holds two batteries and can easily be replaced on-site. If the optional external battery is placed a minimum of 30 cm away from the ADCP, no compass calibration will be required.

Optional Lithium Battery Pack

The optional Workhorse II Lithium Battery Packs can be used interchangeably in Workhorse II Sentinels and the external battery case. This battery pack is assembled using lithium battery cells that provide 34 VDC with a capacity of approximately 1650 Wh. The battery includes a safety circuit that protects the battery and users against short circuits and provides users the ability to test the pack. The circuit also turns the battery off at its end of life before the battery fully discharges. This happens when about 97% of the battery's capacity is depleted (see Workhorse II Lithium Battery Packs).

Mariner Power Overview

The Mariner deck box automatically scales the input voltage to the proper level. No special jumpers or switch settings are required to select the input voltage. If more than one power source is connected to the deck box, the highest voltage source will be used. Although this is not recommended, it will not damage the deck box.

AC Power. The deck box accepts input voltages of 90-264 VAC, 47-63 Hz (J27). This input voltage will be converted to 48 VDC. This is the voltage supplied to the ADCP.

Table 1. Workhorse II Mariner Deck Box Mains Input Power Specification

Parameter	Value Typical	Units
Input Voltage Range (typical):	90 – 132 180 – 264	Vac @auto-ranging, low range Vac @ auto-ranging, high range
Line Frequency (typical):	47 – 63	Hz
Inrush Current (typical):	23 47	A @ 115 Vac @ peak line A @ 230 Vac @ peak line
*Input Power (max):	80 380	W @ during awake or asleep W @ during transmit
Ride Through Time (min):	5 40	ms @ 90/180 Vac low line ms @ 90/180 Vac nominal line

*The 80 and 380 watts are maximum specifications. These have been derived from the maximum power supply rating and the specified minimum efficiency. Actual maximum input power may be lower than the one specified.

12 VDC Car Battery. Use a 12 VDC car battery (J26) when AC power is not available. The deck box converts the voltage to 48 VDC. This is the voltage supplied to the ADCP. Use the largest rated amp-hour battery as possible. A car battery can power a 1200 kHz ADCP for approximately one to two days.

DC Power Supply. If you are using an external DC power supply connected to the deck box on J25 (20 to 50 VDC, 3.0 A), the voltage from the external power supply is sent *directly* to the ADCP. This is useful if you want to increase (higher voltage level) or decrease (lower voltage level) the range of the ADCP. The current requirement for the power supply is listed as a reference. Using a lesser-rated power supply can cause the voltage level to drop. The ADCP will draw only the current it needs.

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

ADCP Internal Batteries. If you want the ADCP to use internal battery power (Sentinel Workhorse II ADCP or external battery pack) rather than the deck box power:

4. Turn OFF or disconnect all power to all ADCP system equipment.
5. Remove the screws on the top cover of the deck box. Lift the cover off.
6. Locate the Filter Interface board (see **Figure 7**). Locate connector J18 and disconnect the twisted black and white cable plugged into this connector. The power from the deck box to the ADCP has now been disabled. Only the batteries are powering the ADCP.

Setting up the Workhorse II System

Use this section to connect the ADCP to a computer and establish communications. Install *TRDI Toolz* and *Workhorse II Plan* software to communicate with the ADCP.

Set Up the Monitor/Sentinel ADCP

To set up the Workhorse II ADCP:

1. Lubricate the cable connector and connect to the ADCP.
2. Attach the cable to the computer's serial communication port or connect the USB adapter to a spare USB port.

> If there is an available internet connection, Windows 10/11 will install the USB driver on first connection. If necessary, install the Virtual COM port (VCP) driver to make the USB adapter appear as an additional COM port. The free FTDI driver download page is available here: https://ftdichip.com/drivers/

- Use a RS-422 to RS-232 converter if the ADCP is configured as RS-422.
- The default factory set communications settings for Sentinel is RS-232, 9600-baud, no parity, 8 data bits and 1 stop bit. Monitor systems default factory set use RS-422, 9600-baud, no parity, 8 data bits and 1 stop bit.

3. Connect +48VDC power to the cable.

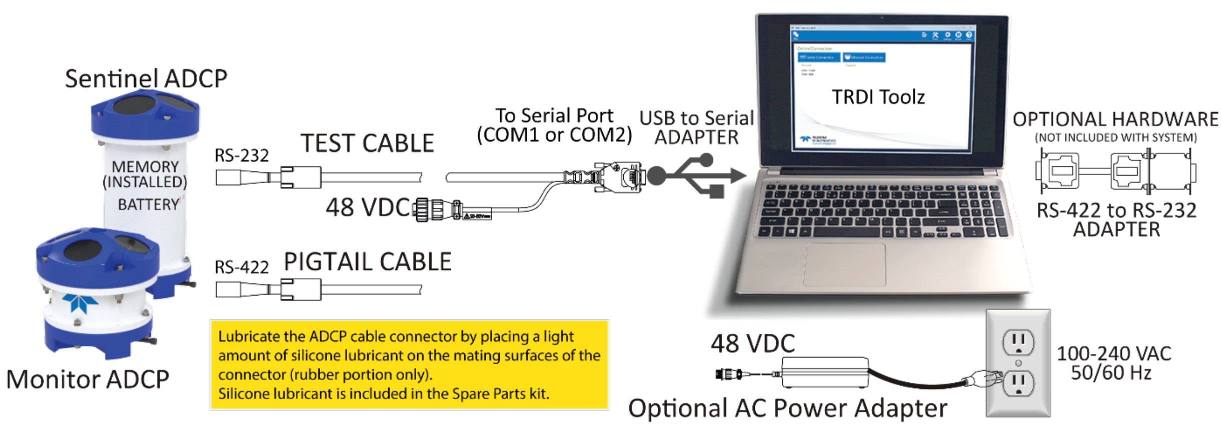


Figure 9. Workhorse II Monitor/Sentinel Connections

> Workhorse II Sentinel batteries are shipped inside the Workhorse II ADCP but **not connected**. Connect the battery and seal the Workhorse II ADCP before deployment.
>
> For testing, the battery can be disconnected to save battery power. If the battery is connected, use the AC power adapter to override the battery voltage to conserve the battery.

Set Up the Marnier ADCP

To set up the WorkHorse Mariner ADCP:

1. Connect the I/O cable (J17) from the Deckbox to the WorkHorse ADCP.

> Use light amounts of silicone lubricant (included in the spare parts kit) on both the rubber portion of the male pins and female socket to help seat the ADCP cable connectors. Wipe off excessive silicone from the metal portions of the pins. **Regular lubrication is required: Apply silicone lubricant prior to each connection.** See I/O Cable and Dummy Plug for details.

2. Attach the serial cable from the Deckbox (J20) for RS-232 or (J19) for RS-422 to your computer's communication port.

- Use RS-232 (J20) when the serial cable to Deckbox is less than 25-meter length.
- Use RS-422 (J19) when the serial cable to Deckbox is greater than 25-meter length. Use a RS-232-to-RS-422 converter if your computer only has a RS-232 COM port.

3. Connect power to the Deckbox.

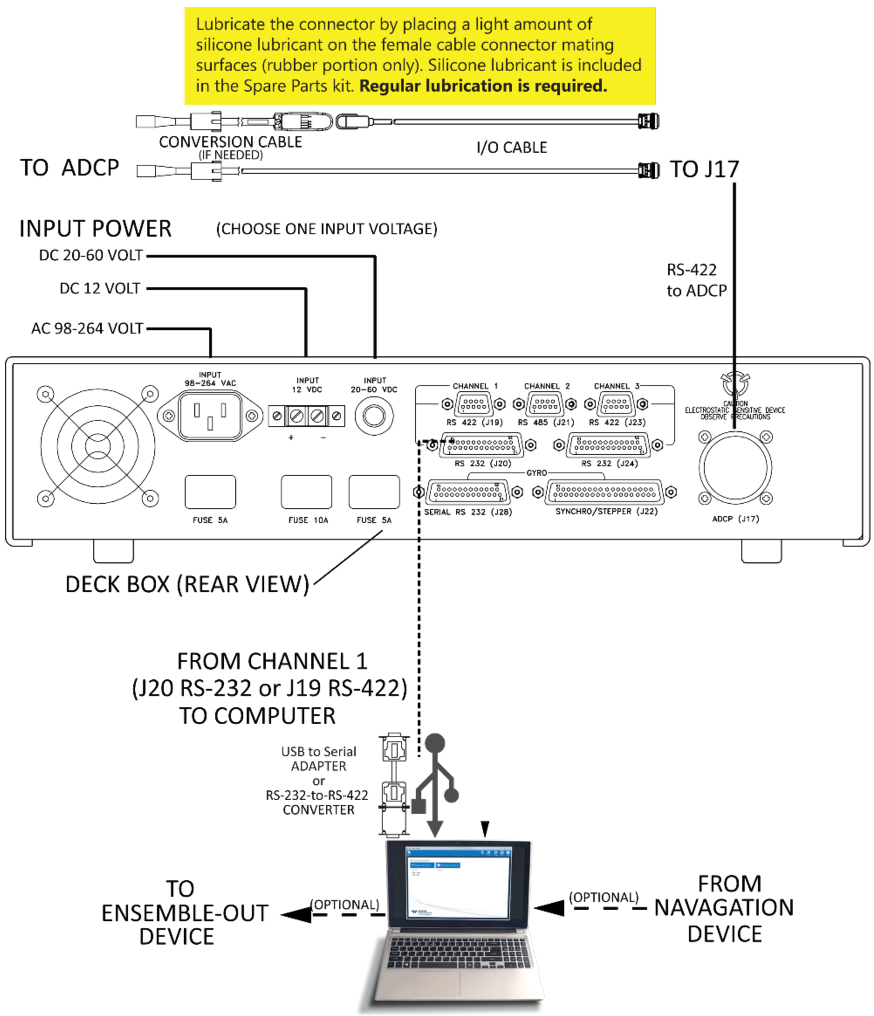


Figure 10. Mariner Connections

Set Up the Mariner ADCP with Trigger In

This requires the WorkHorse Mariner Deckbox with Trigger and the WorkHorse Mariner ADCP communication setting set to RS-232. See Mariner Triggering Function.

To set up the WorkHorse Mariner ADCP:

1. Connect the I/O cable to (J17) from the Deckbox to the WorkHorse ADCP.

   Use light amounts of silicone lubricant (included in the spare parts kit) on both the rubber portion of the male pins and female socket to help seat the cable ADCP connectors. Wipe off excessive silicone from the metal portions of the pins. **Regular lubrication is required: Apply silicone lubricant prior to each connection.** See I/O Cable and Dummy Plug for details.

2. Attach the serial cable from the Deckbox (J20) to your computer's communication port. The standard communications settings are RS-232, 9600-baud, no parity, 8 data bits and 1 stop bit.
3. Connect the Trigger In cable to (J21) on the back of the Deckbox. Pin 6 is (+) and pin 5 is (GND). The input trigger pulse must be a TTL pulse between 15mSec to 38mSec.
4. Connect power to the Deckbox.

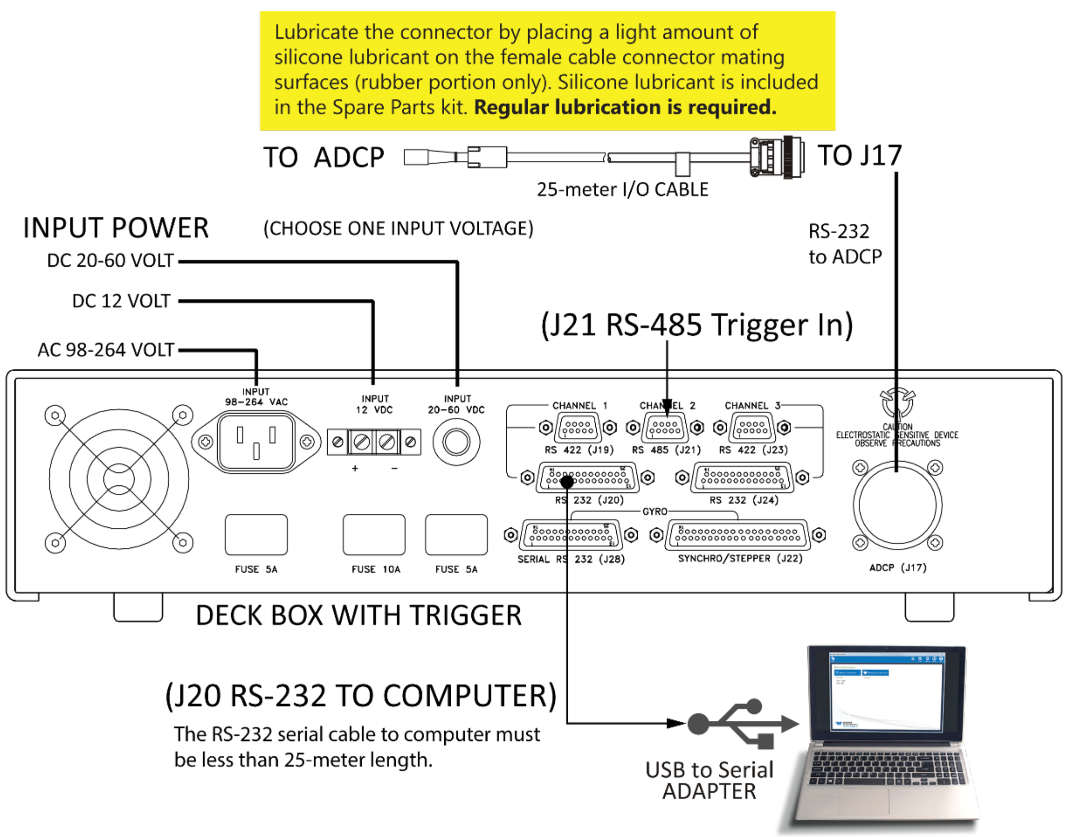
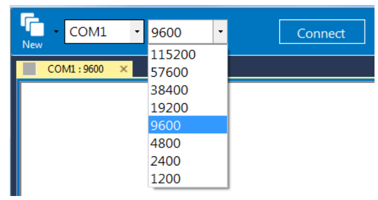


Figure 11. Mariner with Trigger Connections

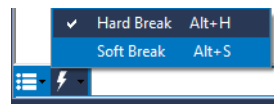
Connecting to the System using TRDI Toolz

To establish communications with the Workhorse II:

1. Connect the system and apply power.
2. Start the *TRDI Toolz* software.
3. Select **New Serial Connection.**
4. Enter the ADCP's communication settings. Select the **COM Port** the serial cable is connected to and set the **Baud Rate** from the drop-down lists.
5. Click the **Connect** button. Once connected, the button will change to **Disconnect**.



6. From the **Break** button drop down menu, select **Hard Break** (shortcut **Alt+H**). Click the **Break** ( ) button. The wakeup banner will display in the terminal window.




```
[BREAK Wakeup A]
Workhorse II Broadband ADCP Version 77.xx
Teledyne RD Instruments (c) 1996-2021
All Rights Reserved.
>
```

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

```
>{¡┐φ²∩╜╜²²jñ~ªñδgJ Checking 9600 baud rate
Checking 115200 baud rate
==
Workhorse II Broadband ADCP Version 77.xx
Teledyne RD Instruments (c) 1996-2021
All Rights Reserved.

>
```

The default factory set communications settings for Sentinel is RS-232, 9600-baud, no parity, 8 data bits and 1 stop bit. Monitor systems use RS-422, 9600-baud, no parity, 8 data bits and 1 stop bit.

For help on using *TRDI Toolz*, click the Help icon.

If you have problems communicating with the system, see Troubleshooting a Communication Failure.

If you don't know what com port(s) were added when using a USB to serial adapter, use *Windows Device Manager*® to determine the Com port. Remove the adapter, wait a moment, note the list of ports, reinsert the adapter and note the new port.

Changing the Baud Rate in the ADCPs

The ADCP can be set to communicate at baud rates from 300 to 115200. The factory default baud rate is always 9600 baud. The baud rate is controlled via the CB-command. The following procedure explains how to set the baud rate and save it in the ADCP. This procedure assumes that you will be using the program *TRDI Toolz* that is supplied by Teledyne RD Instruments.

```
[BREAK Wakeup A]
Workhorse II Broadband ADCP Version 77.xx
Teledyne RD Instruments (c) 1996-2021
All Rights Reserved.
>cr1
[Parameters set to FACTORY defaults]
>
```

Connect the ADCP to the computer and apply power.

Start the *TRDI Toolz* program and establish communications with the ADCP. Use **Alt+H** to switch to a **Hard Break** and then wakeup the ADCP by clicking the **Break** ( ) button.

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

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

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

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

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

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

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

Exit the *TRDI Toolz* program.

The ADCP is now set for the new baud rate. The baud rate will stay at this setting until you change it back with the CB command.

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

Caring for your Workhorse II System

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

General Handling Guidelines

- Never set the transducer on a hard or rough surface. **The urethane faces may be damaged**.
- Do not expose the transducer faces to prolonged sunlight. **The urethane faces may develop cracks**. Cover the transducer faces on the Workhorse II if it will be exposed to sunlight.
- Do not expose the I/O connector to prolonged sunlight. **The plastic may become brittle**. Cover the connector on the Workhorse II if it will be exposed to sunlight.
- Do not store the ADCP in temperatures over 60 degrees C with the batteries removed. **The urethane faces may be damaged**.
- Store batteries in a **cool dry location** (0 to 21 degrees C). If the batteries are installed in the ADCP, do not store the ADCP in temperatures over 21 degrees C.
- Do not store batteries inside the ADCP for extended periods. **The batteries may leak**.
- **Use batteries within one year of the Manufacture date (use by Warning date).** A battery pack used to start a deployment prior to the Warning Date means that it will perform as expected and provide the required power for any deployment that was created using the TRDI planning module. For example, if your deployment is going to be 12 months long and the battery label shows it is nine months old, it is safe to use the battery.
- Vent the system before opening by loosening the vent plug on the end-cap. **If the ADCP flooded, there may be gas under pressure inside the housing**.
- Do not scratch or damage the O-ring surfaces or grooves. **If scratches or damage exists, they may provide a leakage path and cause the ADCP to flood**. Do not risk a deployment with damaged O-ring surfaces.
- Do not lift or support a Workhorse II by the external I/O cable. **The connector or cable will break**.

Assembly Guidelines

- Read the Maintenance section for details on Workhorse II re-assembly. Make sure the housing assembly O-ring stays in the groove when you re-assemble the Workhorse II. Tighten the hardware as specified. **Loose, missing, stripped hardware, or a damaged O-ring can cause the Workhorse II transducer to flood**.
- Use light amounts of silicone lubricant (included in the spare parts kit) on both the rubber portion of the male pins and female socket to help seat the cable connectors. Wipe off excessive silicone from the metal portions of the pins. **Regular lubrication is required: Apply silicone lubricant prior to each connection**.
- Do not connect or disconnect the cable with power applied. When you connect the cable with power applied, you may see a small spark. **The connector pins may become pitted and worn**.
- The Workhorse II cable may be connected while slightly wet; **do not connect under water**.

Deployment Guidelines

- Read the *VmDas* or *WinRiver II* user's guides. **These guides will help you learn how to use the software.**
- Workhorse II Sentinel batteries are shipped inside the ADCP but not connected. **Connect the battery and seal the ADCP before deployment.**
- Align the compass whenever the batteries are replaced, the CompactFlash card is replaced, or when any ferrous metals are relocated inside or around the Workhorse II housing. **Ferro-magnetic materials affect the compass.**

When the batteries are replaced, the compass must be calibrated (see Compass Calibration).

- The AC power adapter is not designed to withstand water. **Use caution when using on decks in wet conditions.**
- Avoid using ferro-magnetic materials in the mounting fixtures or near the Workhorse II. **Ferro-magnetic materials affect the compass.**

NOTES

Chapter 2

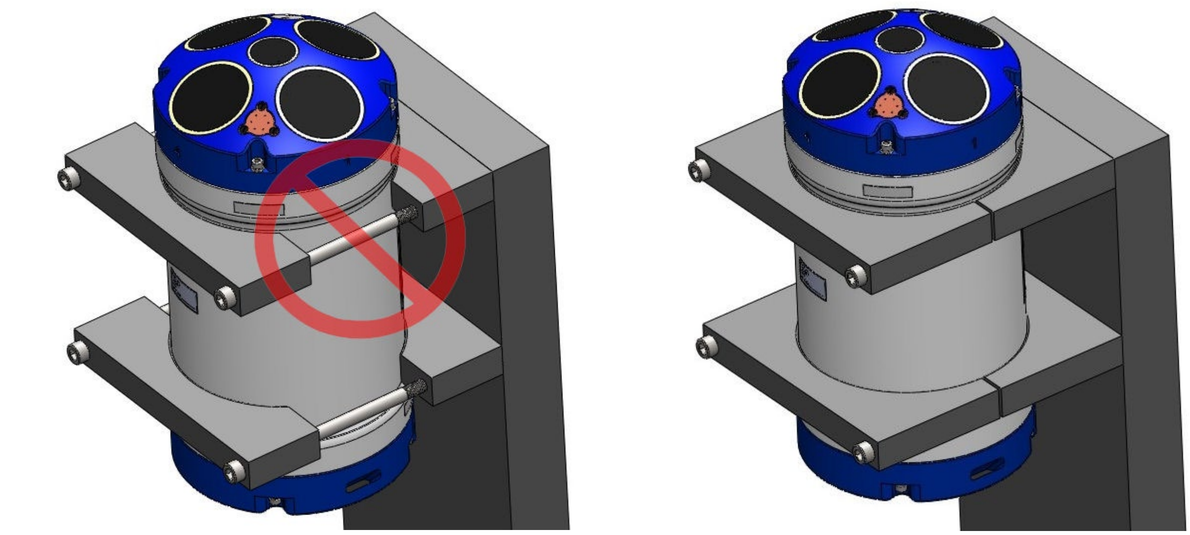
INSTALLATION

In this chapter, you will learn:

- How to connect/disconnect the I/O cable
- How to connect the optional external battery case
- Cable wiring diagrams
- Available mounts for the Workhorse II ADCPs

Mounting the Instrument

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



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

Figure 12. Mounting the Instrument with a Clamp Design

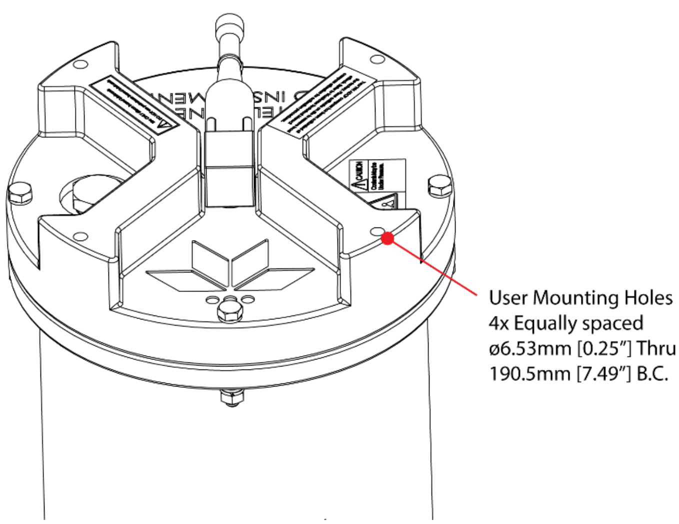


Figure 13. End-Cap User Mounting Holes

Only use stainless steel hardware.

I/O Cable and Dummy Plug

The underwater connector (on the housing) and the cable, conversion cable, and dummy plug use molded wet-mate 8-pin connectors.

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

To disconnect the cable:

1. Turn the locking sleeve counterclockwise until it is fully loose and slides back.
2. Grasp the cable or dummy plug close to the housing and pull the cable or dummy plug straight out away from the connector.

Figure 14. Removing the I/O Cable or Dummy Plug

To connect the cable:

1. Check all pins for signs of corrosion (greenish oxidation, black deposits, or pitting).
2. Use light amounts of silicone lubricant (included in the Spare Parts kit) on both the rubber portion on the male pins and female socket to help seat the cable connectors. Wipe off excessive silicone from the metal portions of the pins. **Regular lubrication is required**: Apply silicone lubricant prior to each connection.
3. Check the keyed portions are properly aligned and insert the dummy plug / cable onto the connector. 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.

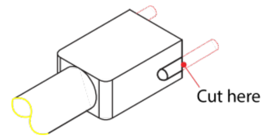
Do NOT use any tools to tighten the locking sleeve ring. It should only be "finger tight".

Using the Cable Clips

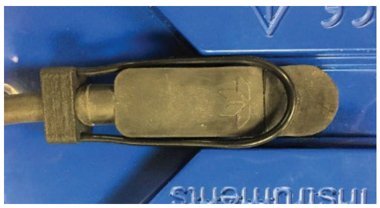
The conversion cable and other cables using the LPMIL-7-FS 7-pin flat connector use cable clips:

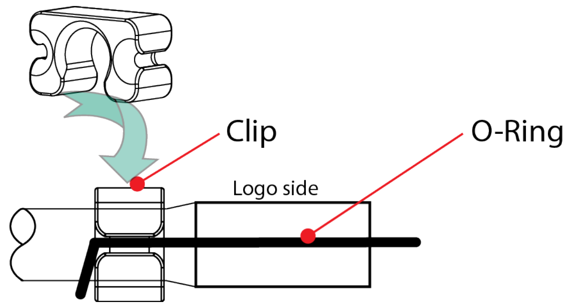
1. Remove the broken retaining strap if needed.
2. Snap the clip onto the cable or dummy plug.

- Black clip & 2-137 O-ring are used for cables
- White clip & 2-130 O-ring are used for dummy plugs



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





Connecting the External Battery Case

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

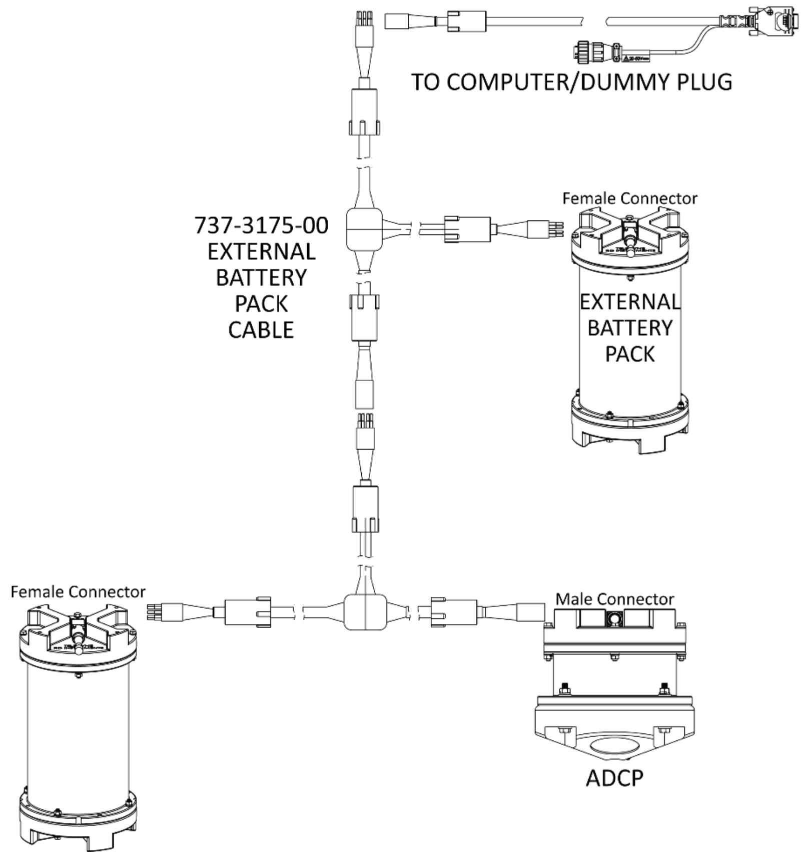


Figure 15. External Battery Pack Connection with "Y" Cable

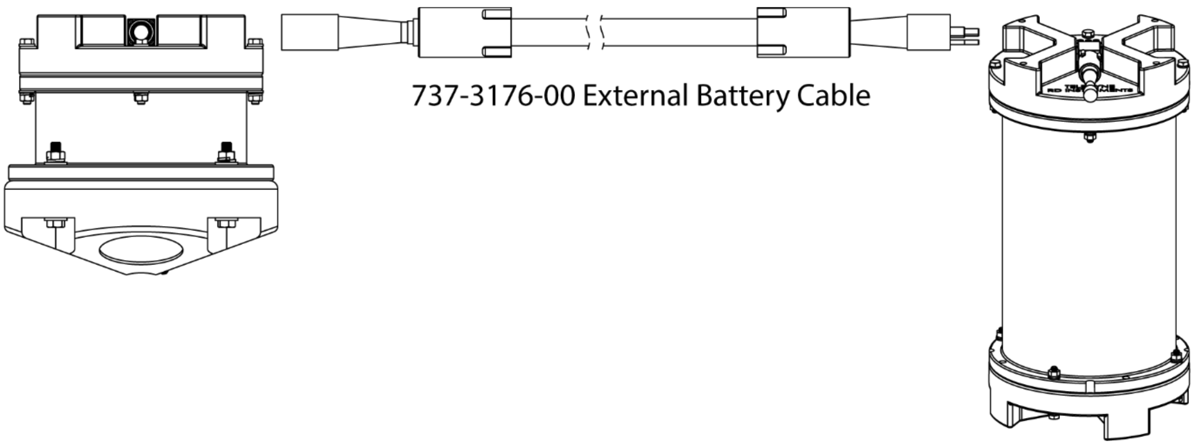


Figure 16. External Battery Pack Connection, Single Battery Case

Routing Cables

Several cables connect to the Mariner ADCP system (see Figure 19). Use care when routing these 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.

The Input/Output (I/O) cable connects the ADCP to the deck box (Mariner systems) or computer. We deliver the cable with both connectors attached. The transducer-end connector is molded on, so you can use it below the waterline. The cable is custom-made in lengths specified by the user. Route this cable so:

- You can install it with the connectors attached.

You can order the cable with the deck box end connector removed for easier cable routing, but this requires soldering the cable connections at your installation site. This is a difficult task (see Mariner I/O Cable Dry End Connector Assembly).

- It does not have kinks or sharp bends.
- Protect the cables with hose if zip-ties are used to secure them to structures (see Figure 17 and Figure 18).
- Secure all cables to the mounting structure in such a manor so that no forces are exerted on any connector. Secure the cable as close to the connector as possible without causing any stress to the connector.
- You can easily replace it if it fails.
- The Mariner dry-end connector OD is 3.89cm (1.530 inches) and is 5.02cm (1.976 inches) long. Model# Souriau 85106RC2024P50.
- The wet-end connector is an Impulse MCIL-8-FS which is 2.09cm (0.82 inches) long, 0.62cm (0.24 inches) diameter or it may use the Impulse LPMIL-7-FS which is 3.0cm (1.18 inches) long, 2.54cm (1.00 inches) wide, 1.27cm (0.5 inches) high.

Other cables that may need routing to the chassis include the computer interface, and the navigation interface. You may also need to route the External Battery case cables.

Figure 17. Do not use Zip-Ties Directly on Cables

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

Figure 18. Cables Protected with Abrasion Resistant Sleeving

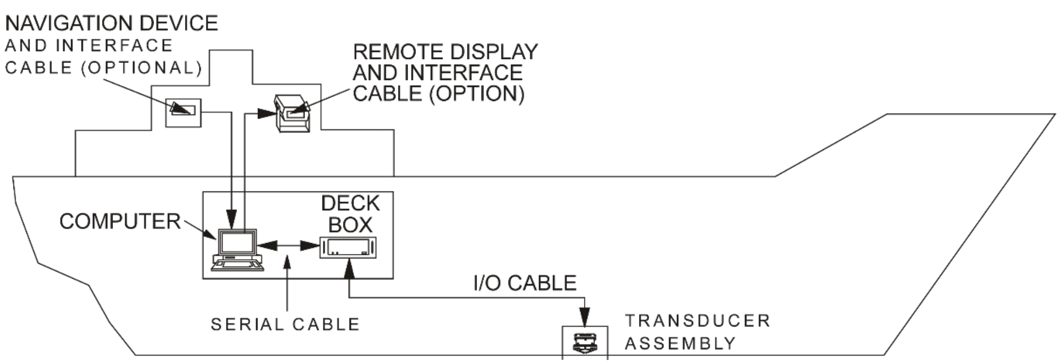


Figure 19. Typical Mariner Interface Cable Layout (Overview)

Cable Wiring Diagrams

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

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

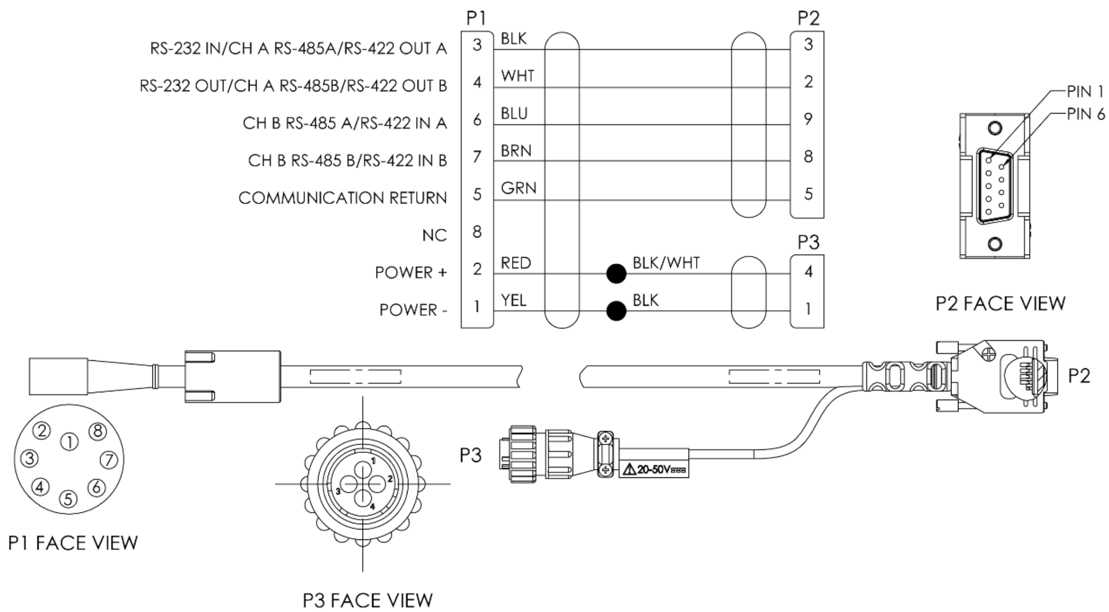


Figure 20. Monitor and Sentinel I/O Cable 737-3172-xxx Wiring

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

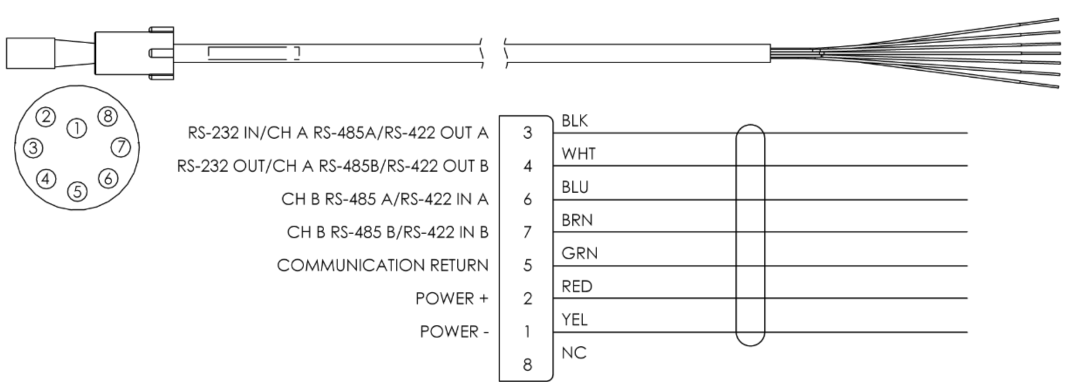


Figure 21. Monitor Pigtail I/O Cable 737-3173-xxx Wiring

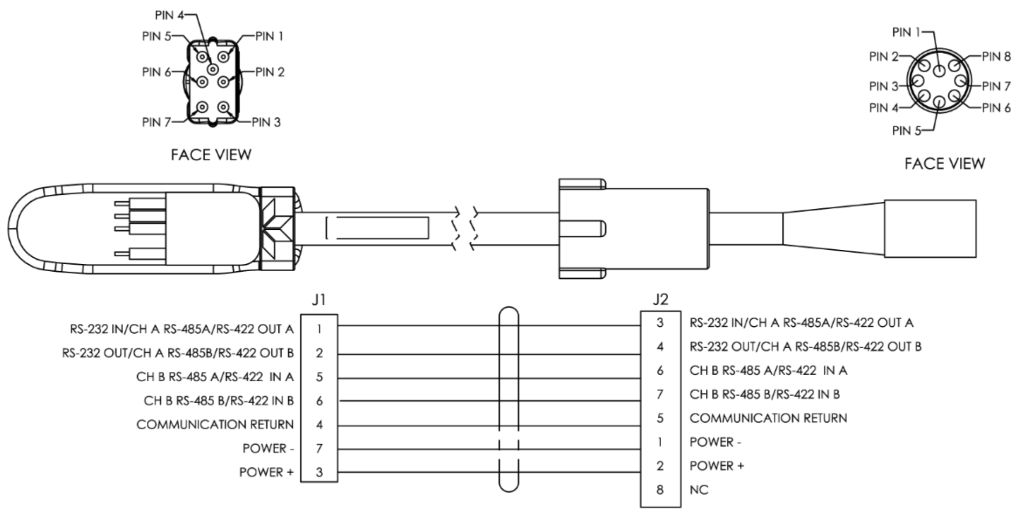


Figure 22. Conversion Cable (0.5 meter) Wiring 737-3171-00

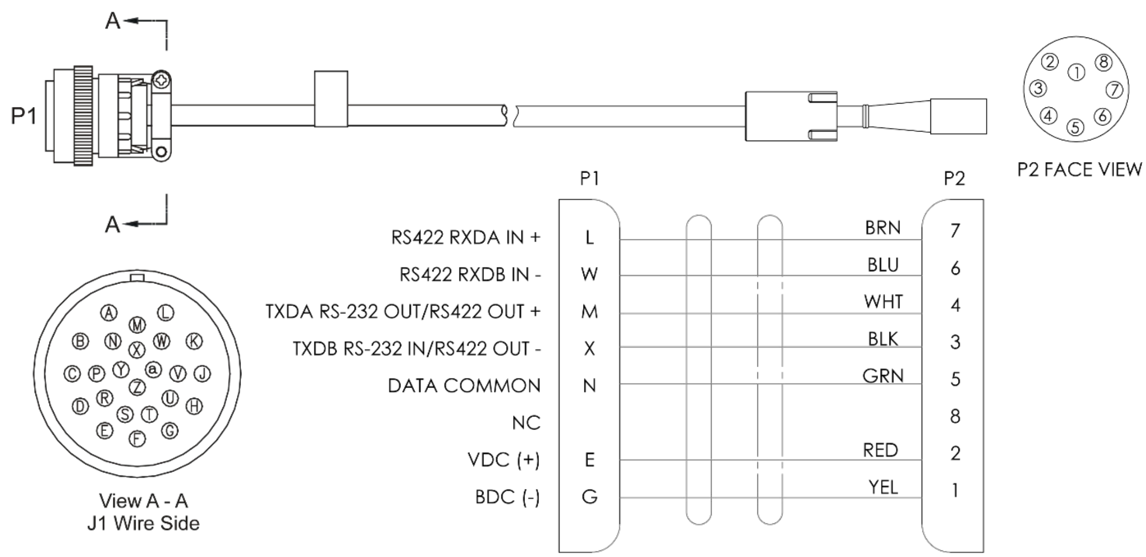
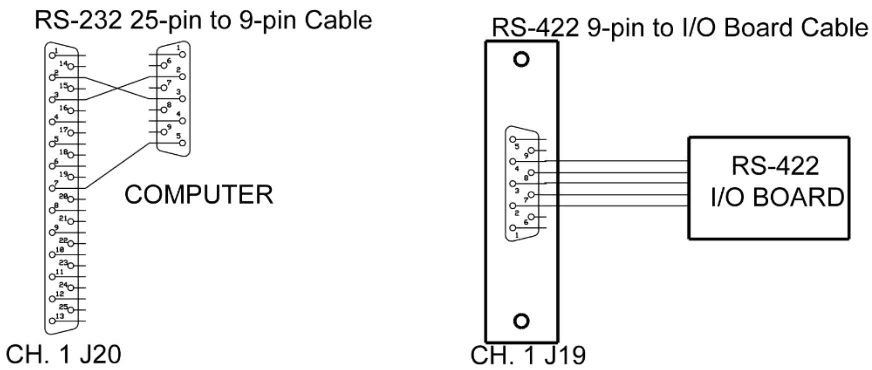


Figure 23. Mariner I/O Cable Wiring 737-3177-XXX

For reliable communications, the Mariner I/O Cable (J17) cable from the Deck Box with Trigger to the Mariner must be no longer than 25-meters. See Mariner Triggering Function.



Cable Type	ADCP Signal	Chassis	Computer	Computer Signal
RS-232 25-pin to 9-pin	DATA IN DATA OUT GND	2 3 7	3 2 5	DATA OUT DATA IN GND
RS-422 9-pin to I/O board	DATA IN A DATA OUT A COMMON DATA IN B DATA OUT B	2 4 3 7 8	- - - - -	DATA OUT A (+) DATA IN A (+) COMMON DATA OUT B (-) DATA IN B (-)

Figure 24. Mariner Deck Box to Computer Serial Cable

These cables provide RS-232 or RS-422 communications. One 25-pin Female to 9-pin Male RS-232 cable is provided with the instrument (P/N 730-6003-00). The cable is about 2-meters long and has a diameter of 8 mm (0.31 in.).

For cable lengths longer than 15 meters, we recommend you use RS-422 communications. The cable for RS-422 communication is not provided with the equipment.

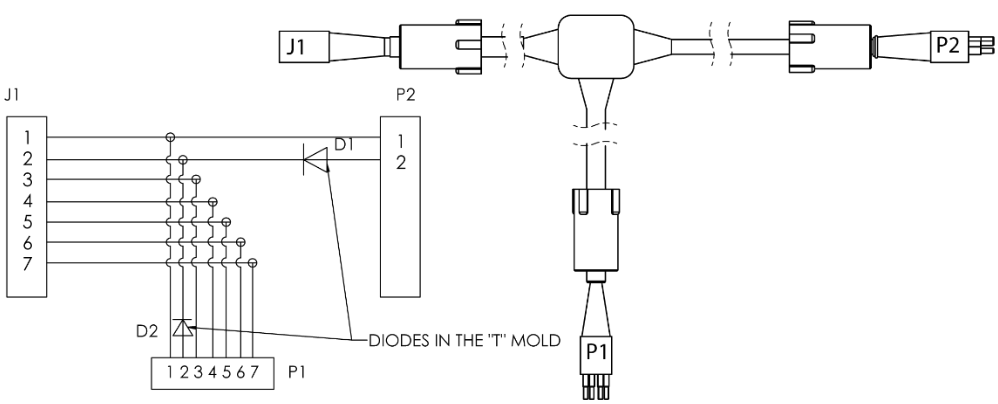


Figure 25. External Battery Pack "Y" Cable 737-3175-00

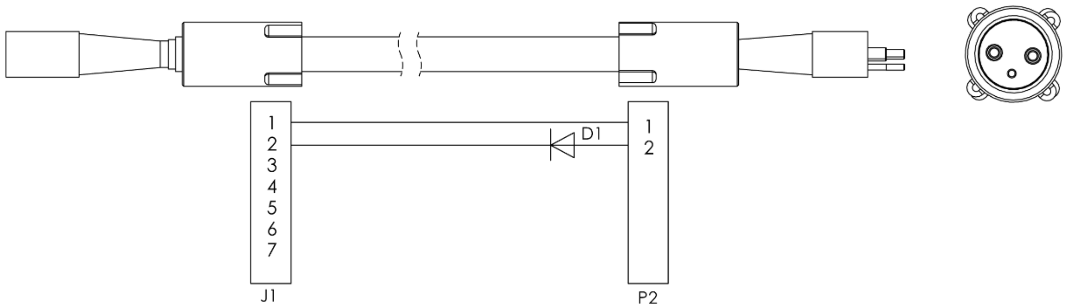


Figure 26. External Battery Pack Cable 737-3176-003

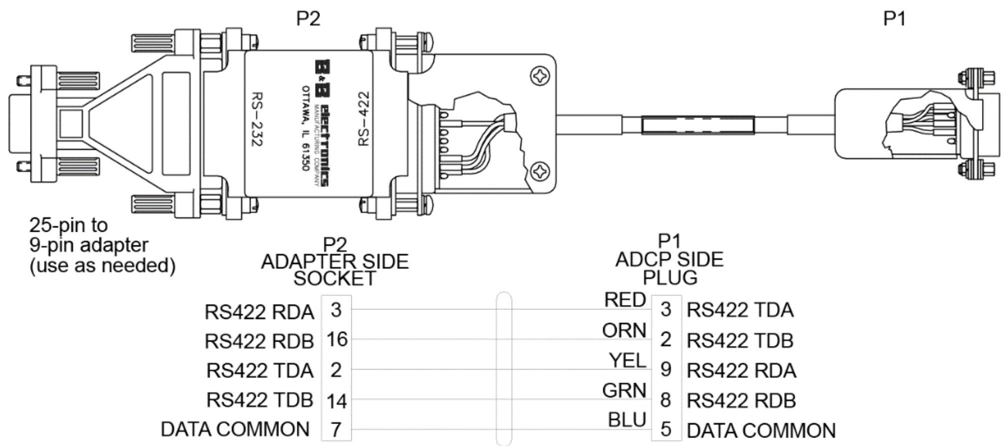


Figure 27. RS232-to-RS422 Converter Wiring (25-Pin to 9-Pin)

Bottom Mounts

Bottom mounts can range from simple PVC frames to Trawl Resistant Bottom Mounts. Below is a sample of some of the types of bottom mounts available for Workhorse II ADCPs.

Figure 28. Teledyne RD Instruments Sea Spider Bottom Mount

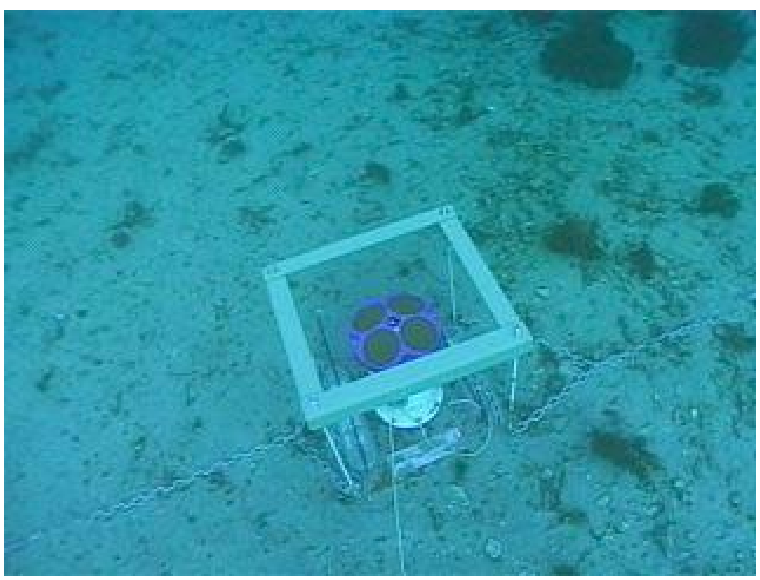


Figure 29. View from the Bottom

Photo courtesy of John Skadberg, US Navy SPAWAR System Center in San Diego, CA. Sent to TRDI by Steve Monismith.

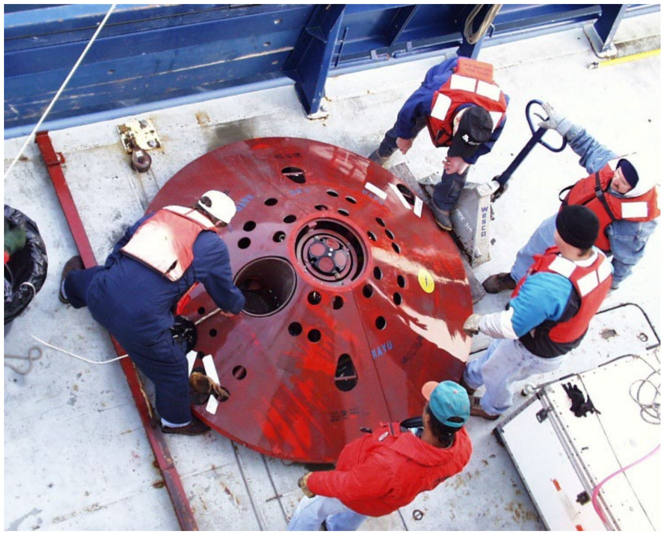


Figure 30. Trawl Resistant Bottom Mount

Photo courtesy of Maureen Wieler, Mooring Systems.

Buoy Mounts and Load Cages

Buoy mounts and load cage frames are designed to allow the Workhorse II to profile unobstructed by the mooring hardware. Below is a sample of some the types of buoy and load cage mounts available for Workhorse II ADCPs.

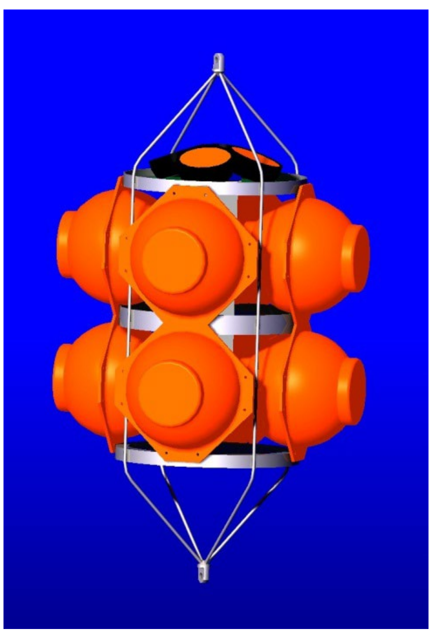


Figure 31. Deep-Water Mount

Photo courtesy of the Oceanscience Group.

Figure 32. Buoy Mount with External Battery

Photo courtesy of Maureen Wieler, Mooring Systems.

Figure 33. Subsurface Buoy

Photo courtesy of Patrick Lefeuvre, Technicap. The Subsurface buoy was developed by BMTI and Technicap.

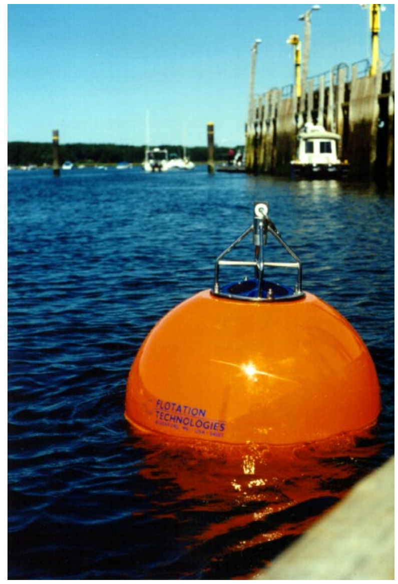


Figure 34. Buoy Mount

Photo courtesy of Flotation Technologies.

Figure 35. Load Cage

Photo courtesy of Angela Cates, UNM.

Over-the-Side Mounting

The over-the-side mount is common if you want the ability to move the ADCP from one platform to another. Make the mount as rigid as possible to limit the amount of pitch and roll applied to the ADCP. Although the tilt sensor can measure a ±20° influence, anything beyond 15° will cause bias to the data that cannot be removed. No matter what mounting style is used, the ADCP must be below the bubble layer.

Bubbles will cling to the urethane faces of the ADCP and reduce the range to almost nothing. Usually a mount somewhere aft of amidship is used. A stern mount will cause all sorts of problems due to propeller wake, bubbles, and turbulent water conditions.

The most common over-the-side mounting method for Workhorse II ADCPs uses a Kentucky Mount style. For more information, see the following:

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

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

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

The Workhorse II ADCP has mounting holes on the end-cap. See the Outline Installation Drawings for weights.

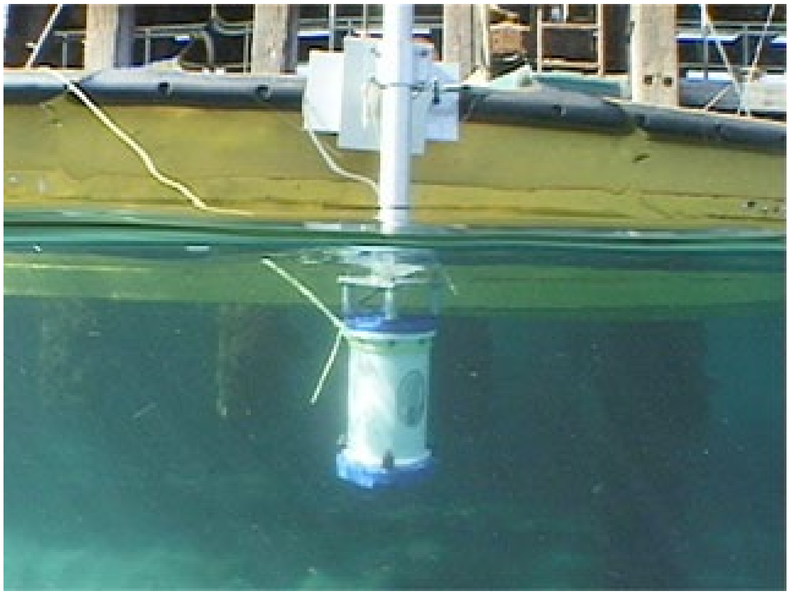


Figure 36. Over-the-Side Mount

Photo courtesy of John Skadberg, US Navy SPAWAR System Center in San Diego, CA. Sent to TRDI by Steve Monismith.

Over-the-Side Mounting Special Considerations

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

- It is desirable to rigidly mount the ADCP to the platform. You want to avoid the free spinning of the ADCP in this application. The ADCP must stay in the water at all times.
- The ADCP must be mounted deep enough so that turbulence caused by its movement through the water does not allow air bubbles to be attached to the transducer faces.
- Avoid mounting the ADCP near motors and thrusters. They cause air bubbles and will cause bias to the internal compass.
- Avoid mountings that will cause the ADCP to see severe accelerations.

In-Hull Mounting

The in-hull mounted ADCP is common when it is intended to keep the system on a single vessel or when over-the-side mounting is not practical for your vessel. For this type of mounting, there are issues of beam clearance and access.

Transducer Head Mounting Considerations

You must consider several potential problems before installing the transducer head assembly. Read this section before deciding where to install the transducer assembly. See the outline installation drawings for specifications on our standard ADCP transducer heads.

Mounting Plate Overview

The Mariner mounting plate is a bronze plate that helps mount the transducer head to a vessel. The overall dimension of the mounting plate is ∅311.1 (12.25 inches) and the bolt hole pattern is 16 equally spaced ∅8.20 through holes on a ∅285.75 bolt circle.

See the outline installation drawings for the exact dimensions and weights.

Location

Ideally, you want to install the transducer head:

- Where it is accessible both internally (for access to transducer electronics) and externally (to remove biofouling).
- Away from shipboard protrusions that reflect ADCP energy. Allow for a reflection-free clearance of 15° around each beam (see the outline installation drawings).
- Away from other acoustic/sonar devices, especially those operating at the same frequency (or harmonic) of the ADCP.
- Close to the ship's fore-to-aft centerline. As distance from the centerline increases, vertical accelerations caused by the roll of the ship also increase. These accelerations can cause additional uncertainties in ADCP velocity measurements.

Other considerations may be:

- Ease of installation.
- Portability (wanting to move the instrument from vessel to vessel).
- Permanent installation.

With all these choices, there are good and bad points. We will show you several options for installation and then go through specific concerns that you may have to deal with once you install or mount the ADCP.

Sea Chest In-Hull Mounting

A sea chest (**Figure 37** and **Figure 38**) is a fixture that surrounds and holds the transducer head, protecting it from debris in the water. The bottom of the sea chest must be open to seawater to allow the acoustic beams to pass through freely. If using a sea chest interests you, call TRDI for the latest information.

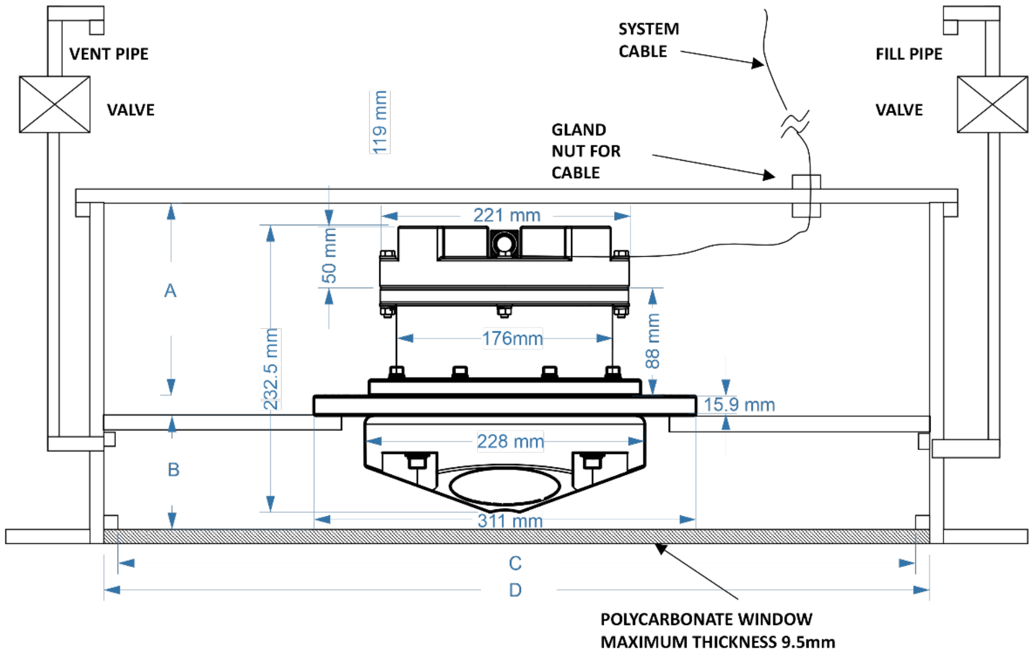


Figure 37. Inside Vessel Mounting of a Workhorse II Mariner 300 kHz Transducer

Dimension Letter	Option 1 Minimum Dimension	Option 2 Maximum Dimension
A	275.4mm	275.4mm
B	84.7mm	91.1mm
C	362mm	362mm
D	412mm	412mm

Special Notes:

1. No liability is assumed by Teledyne RD Instruments for users using this conceptual well drawing. Users realize that this drawing is provided as a basis for the user to construct their own well. It is expected that the user will have their well design inspected and approved by a naval architect.
2. The top plate of the well is intended as the primary seal for the vessel. The window and transducer can provide additional seal but should not be considered the primary sealing mechanism for the vessel.
3. This conceptual well drawing is designed such that it would be possible to remove the transducer from inside the vessel. For safety, it is strongly recommended that divers fit a steel plate either over the window or in place of the window before installing or removing the transducer.
4. The listed minimum and maximum dimensions are recommendations based on maintaining the clearance for the transducer as well as providing the smallest well possible.
5. The gasket material between the transducer housing and the vessel flange should be used that will both seal and provide electrical isolation between the transducer housing and the vessel flange. Typical gasket material used is silicone rubber 3-6.35mm thick.
6. Inserts in the transducer housing mounting holes may be used to provide additional isolation from vessel.
7. The walls of the well should be coated with a material to absorb reflected sound in the well. Material such as 3mm wet suit material glued to the inside well walls is satisfactory for this purpose.
8. Vent and fill pipes should be above the water line of the vessel and it is recommended that a gate valve be installed to seal off these pipes.
9. Window thickness should not exceed 9.5 mm of Polycarbonate material. Thinner Polycarbonate window is OK.
10. Window faces should be parallel to the transducer face to within 2 degree for best performance; angle should never exceed 5 degrees.

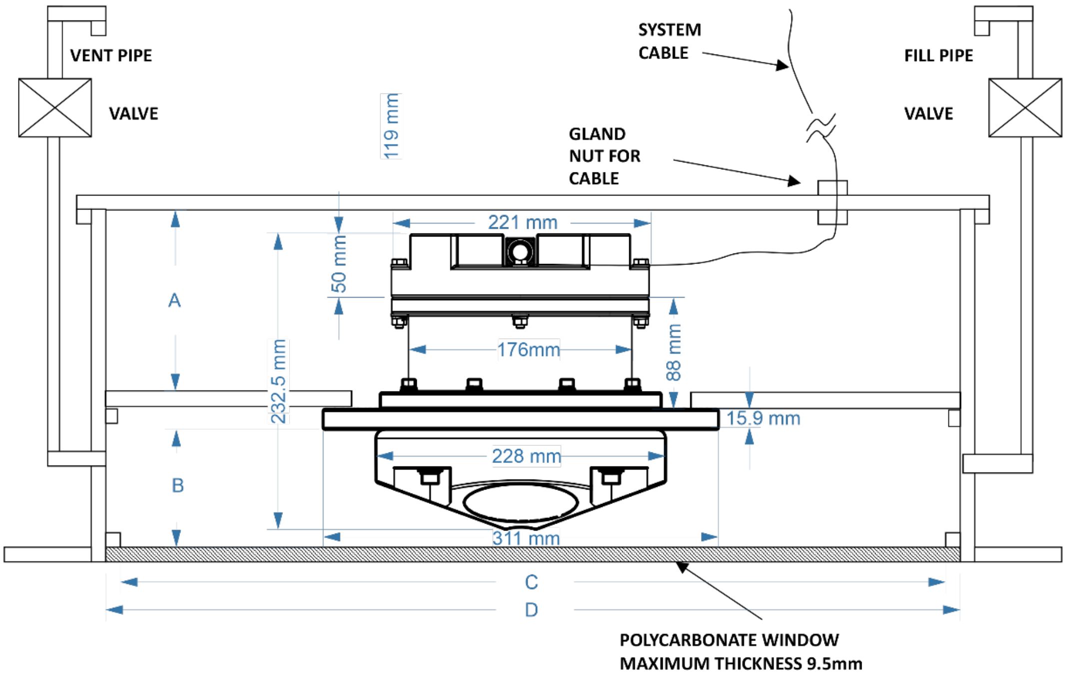


Figure 38. Underneath Vessel Mounting of a Workhorse II Mariner 300 kHz Transducer

Dimension Letter	Option 1 Minimum Dimension	Option 2 Maximum Dimension
A	275.4mm	275.4mm
B	84.7mm	91.1mm
C	362mm	362mm
D	412mm	412mm

Special Notes:

1. No liability is assumed by Teledyne RD Instruments for users using this conceptual well drawing. Users realize that this drawing is provided as a basis for the user to construct their own well. It is expected that the user will have their well design inspected and approved by a naval architect.
2. The top plate of the well is intended as the primary seal for the vessel. The window and transducer can provide additional seal but should not be considered the primary sealing mechanism for the vessel.
3. This conceptual well drawing is designed such that it would be possible to remove the transducer from beneath the vessel while in dry dock.
4. The listed minimum and maximum dimensions are recommendations based on maintaining the clearance for the transducer as well as providing the smallest well possible.
5. The gasket material between the transducer housing and the vessel flange should be used that will both seal and provide electrical isolation between the transducer housing and the vessel flange. Typical gasket material used is silicone rubber 3-6.35mm thick.
6. Inserts in the transducer housing mounting holes may be used to provide additional isolation from vessel.
7. The walls of the well should be coated with a material to absorb reflected sound in the well. Material such as 3mm wet suit material glued to the inside well walls is satisfactory for this purpose.
8. Vent and fill pipes should be above the water line of the vessel and it is recommended that a gate valve be installed to seal off these pipes.
9. Window thickness should not exceed 9.5 mm of Polycarbonate material. Thinner Polycarbonate window is OK.
10. Window faces should be parallel to the transducer face to within 2 degree for best performance; angle should never exceed 5 degrees.

Mounting Considerations

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

Orientation

We recommend you mount the transducer head with Beam 3 rotated to a ship-relative angle of 45° (**Figure 40** shows beam orientation). This causes the magnitude of the signal in each beam to be about the same. This improves error rejection, reduces the effect of ringing (see Acoustic Isolation), and increases the ADCP's effective velocity range by a factor of 1.4. If you align Beam 3 at an angle other than zero, you must nullify this offset. You can do this using a direct command (see the Workhorse II Command Guide) or through our *VmDas* program.

Use the ship's roll and pitch reference to mount the transducer head as level as possible. If the head is not level, depth cell (bin) mapping will be incorrect. Large misalignments can cause large velocity measurement errors. If you cannot mechanically make the transducer head level, you can use *VmDas* to enter offset values for roll and pitch.

Fairing

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

Acoustic Window

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

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

Advantages

- Well will not fill with air bubbles caused by the ship moving through the surface water, see Sea Chest In-Hull Mounting.
- Flow noise is reduced, see Flow Noise.
- 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 ADCP will be reduced because the window can and will absorb some of the transmit and receive energy.
- The transmit signal could be reflected into the well, causing the well to "ring" like a bell. This will cause the data being collected during the ringing to be biased. Some ships have reported a loss in range as great as 50 meters. The ringing may be dampened by applying sound absorbing material on the well walls (TRDI does not have any recommendations for sound absorbing material), see Ringing.

- The transmit signal could be reflected off the window and back into the other beams.

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

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

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

Our experience has shown that Polycarbonate windows are very good for the Ocean Surveyor/Observer (OS), Workhorse II (WH), and Broadband (BB) ADCPs. The thickness of the materials depends on the frequency you intend to use. **Table 2** will help to choose the maximum thickness you should use.

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

Table 2: Window Thickness

Frequency	Recommended Thickness	Maximum Thickness
75	1 inch	2 inches
300	0.375 inches	1 inch
600	0.25 inches	0.5 inches
1200	0.25 inches	0.5 inches

Spacing between window and transducer. The primary geometrical factor in design of windows is the reflection of one beam into another beam, causing crosstalk between the beams. The distance from the window should be at least 0.25 inches and no more than 0.5 inches for optimal set up.

Window aperture. The window aperture must be sufficient to pass the beams without causing diffraction. If the window is placed next to the transducer, then the aperture diameter should be the same as the distance between transducer cup corners. If the window is placed away from the transducer, then the aperture should be larger than all four beams plus about one transducer ceramic diameter.

Free Flow and Windows

If filling and draining the well is an issue, then you may want to use a window but allow the water to freely exchange from outside the well to inside the well.

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

It is best if the window is parallel to the bottom edge of the transducer cups. The transducer cups are at a 30° angle. If the window is at an angle to the transducer, it will change the absorption. We do not have experience with different angles, but we have had customers use domes or have the window follow the contour of the ship bottom without real problems.

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

Acoustically-absorbing sea chest liner. A sound absorbing material should be used inside the sea chest to minimize the effects of sound ringing within the sea chest. The material should be a minimum of one wavelength thick (include the sound speed of the absorbing material when calculating the size of a wavelength). Approximate wavelengths of sound in seawater are given below in **Table 3**. We do not have sufficient experience to recommend a specific absorbing material.

Table 3: Wavelength of sound in seawater (1500 m/s sound speed)

FREQUENCY (kHz)	WAVELENGTH (mm)
75	20
300	5
600	2.5
1200	1.25

Fluid in the sea chest. If you have not placed holes in the window and you are not going to work in an area where freezing is an issue, then the sea chest should be filled with fresh water. Fresh water decreases the issues of corrosion in the sea chest. If you will be in an area where freezing of fresh water would be an issue, then seawater can be used.

Only use Propylene Glycol and not Ethylene Glycol because the latter can harm the transducer urethane over time.

Some users have placed Propylene Glycol into the fresh water well to prevent freezing. TRDI recommends using a 40% Polypropylene Glycol + 60% freshwater mixture or 10% Polypropylene Glycol + 90% freshwater mixture depending on the water freezing temperature. Although this causes the water to have an inverted speed of sound (SoS) change to that of fresh water or salt water, SoS does not impact 2D velocities on a Phased Array Transducer.

You will have to perform post processing on the data sets from the Workhorse II. It must have the velocity data scaled properly based on the speed of sound in the sea chest. Propylene glycol causes the water to have an inverted speed of sound change to that of fresh water or salt water. This means that TRDI's standard software programs will not be scale the data properly. You will have to record separately the speed of sound in the sea chest and then in post processing correct the ADCP velocity data appropriately.

Transducer calibration. The factor used to correct velocity for speed of sound variations should be based on the speed of sound of the fluid inside the sea chest. Changes of speed of sound resulting from temperature changes may be computed from the temperature sensor on the transducer.

Air Bubbles

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

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

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

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

Flow Noise

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

Corrosion and Cathodic Disbondment

Your ADCP is made of plastic and uses titanium bolts. The adapter plate (if used) may be naval bronze, aluminum, or other materials. Although the plastic ADCP will not corrode, the bolts and adapter plate may corrode.

Never attach anodes directly to the transducer head. Standard anode protection used for the ship should be installed outside of the well of the transducer head. Mounting of ship's standard anode protection outside of the transducer well will typically protect the parts that may corrode. However, you should plan regular inspections of mounting hardware and the adapter plate for signs of corrosion. Replace and parts that are questionable (corrosion can be further reduced if the well is covered with a window and then filled with fresh water).

Ringing

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

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

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

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

All ADCPs "ring" for some amount of time. Therefore, each ADCP requires a blanking period (time of no data processing) to keep from processing the ringing energy. Each ADCP frequency has a different typical ringing duration. The typical ringing period for each ADCP frequency is as follows; 75kHz is 8 meters, 300kHz ADCPs is 2 meters, 600kHz ADCPs is 1.5 meters, and 1200kHz ADCPs is 0.8 meters. These typical ringing values are recommended as the minimum setting for all ADCPs using default set ups.

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

The window causes the transmit signal to reflect back into the well due to the difference in impedance between the window and the water. When the transmit signal is reflected in the well it becomes trapped and this results in longer ringing periods. To keep from processing this signal, the blanking period must be increased.

Lining the inside walls of the well with a sound absorbing material aid in dampening the ringing effect.

Acoustic Isolation

Try to minimize the acoustic coupling between the transducer head and the ship. Without adequate acoustic isolation, the transducer output will “ring” throughout the ship and feeds back into the ADCP receive circuits. Ringing causes bias errors in water-track velocities and results in the loss of data in the closest depth cells (bins). Reflections inside a sea chest with an acoustic window also can cause ringing.

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

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

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

- Transducer mounted to a thin steel plate
- Steel plate positioned with three pins set into mounting holes on the hull; pins isolated with gaskets
- Steel plate held in place with four I-beams welded to a frame
- Frame bolted to another frame and separated by gaskets
- Second frame bolted to the ship and separated by gaskets

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

- Mount the other acoustic devices as far apart as possible.
- Make sure neither the main lobes nor the side lobes of the acoustic devices point at the transducers, including acoustic reflections.
- Try not to operate devices that use the same frequency or a harmonic of the ADCP’s frequency.

Maintenance

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

Vessel mounted Workhorse II ADCPs are subject to biofouling. Soft-bodied organisms usually cause no problems, but hard barnacle shells can cut through the urethane transducer face causing transducer failure and leakage into the ADCP (see **Figure 39**).

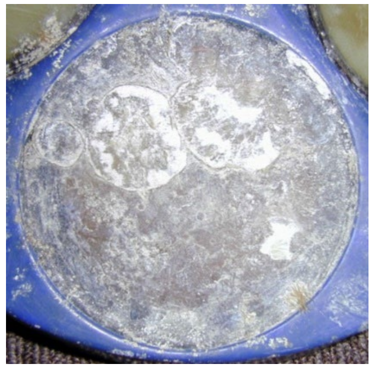


Figure 39. Barnacle Damage to Urethane Face

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

Mariner Deck Box Mounting Considerations

Place the Mariner Deck Box (see Outline Installation Drawings) where there is access to the I/O cable, host computer, and navigation interface cable. The chassis needs an input voltage of 90 to 260 VAC or 12 VDC to operate (see Power Considerations). Allow enough room around the Deck Box for access, ventilation, and isolation from electronic and magnetic interference.

Navigation Interface Considerations

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

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

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

For more information about NMEA data, see the VmDas and WinRiver II User's Guides.

Installation Procedures (Overview)

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

The following procedure applies to Workhorse II Mariner ADCPs. Some parts may apply to Workhorse II Monitor/Sentinel ADCPs if they are being mounted to a vessel.

1. On receipt of the system, read the Workhorse II Operation Manual.
2. Before installing the system, test the transducer and deck box right out of the shipping container. Do the following.

a. All power to the system DISCONNECTED.

b. Review Power Considerations.

c. Connect the I/O cable from the deck box to the ADCP.

d. Connect the serial I/O cable from the computer to the deck box.

e. Connect the power cable to the deck box and apply power to the system (the Routing Cables section shows all cable connections).

f. Follow testing procedures in Testing the Workhorse II . Test the system. If errors occur, use Troubleshooting.

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

4. Review Transducer Head Mounting Considerations. Install the transducer head. Mechanically align the system (see Alignment Procedures (Overview)).

> Take steps to prevent leaks through the hull and gate valves.

5. Review section Mariner Deck Box Mounting Considerations. As necessary, do the following.

a. Install the deck box.

6. Review Computer Considerations. Install the computer.

7. Review Cabling Considerations. As necessary, route and connect the following cables:

- Transducer to deck box (J17) interface cable.
- Navigation to computer cable.

> Signals may be present.

8. As necessary, load the software on the computer's hard drive. See the Software User's Guide and the Help files for each program.

9. Configure *VmDas* or *WinRiver II*. See the software's help file and the *VmDas* or *WinRiver II* User's Guide for help on configuring the program.

10. Do the Dock Side Tests (see Dock Side Tests). If errors occur, use Troubleshooting.

11. Do the Sea Acceptance testing (see Sea Acceptance Tests). The Sea Acceptance tests include the following checks.

- Interference
- Water Profile Range
- Ringing and (cross-coupling, other pingers, noise)
- Water Profile Reasonableness (transducer alignment)
- Bottom-track (range, accuracy)

Alignment Procedures (Overview)

This section does not apply to stationary systems (such as bottom mounted Sentinels). These systems use an internal compass by default.

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

VmDas uses the **Heading Correction Parameters** on the **Transforms** tab to align the ADCP's north reference (Beam 3 mark) to the north reference of an external compass. Ships use the bow as the north reference.

When the Workhorse II is aboard a vessel, the mechanical alignment of the transducer head (Beam 3 mark) is usually aligned with the ship's fore-to-aft centerline (0°) or rotated 45° clockwise. To conceptually determine the misalignment angle, visually hold the ADCP still and turn the ship north reference to match the ADCP's north reference. For example, if the Beam 3 mark is pointing at the bow (**Figure 40**), the misalignment angle is zero. If the Beam 3 mark is pointing 45° to starboard (**Figure 40**), you must turn the ship a +45° to align the two north reference points. Conversely, if the Beam 3 mark is pointing 45° to port, you must turn the ship a -45° to align the two reference points.

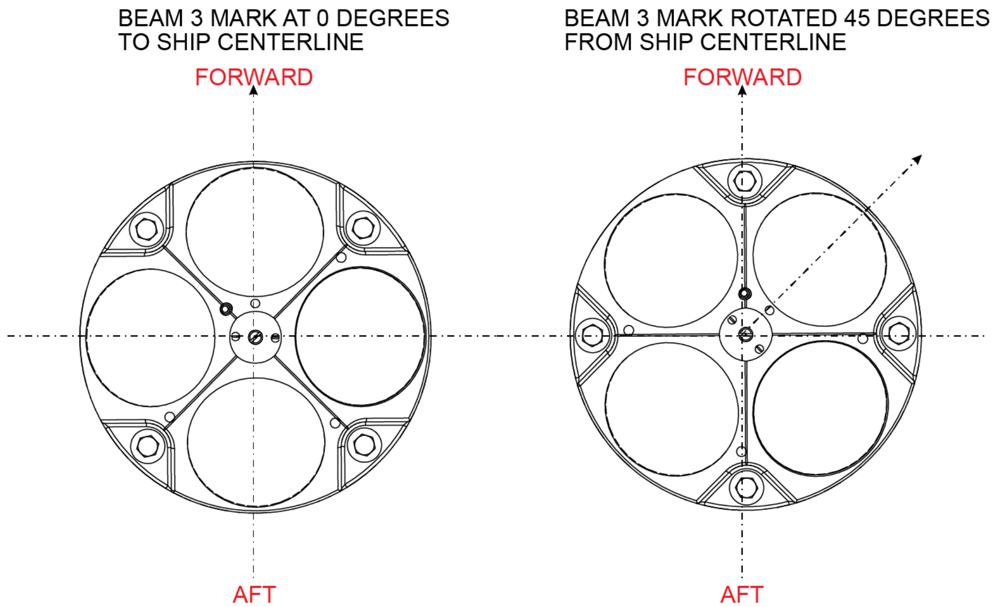
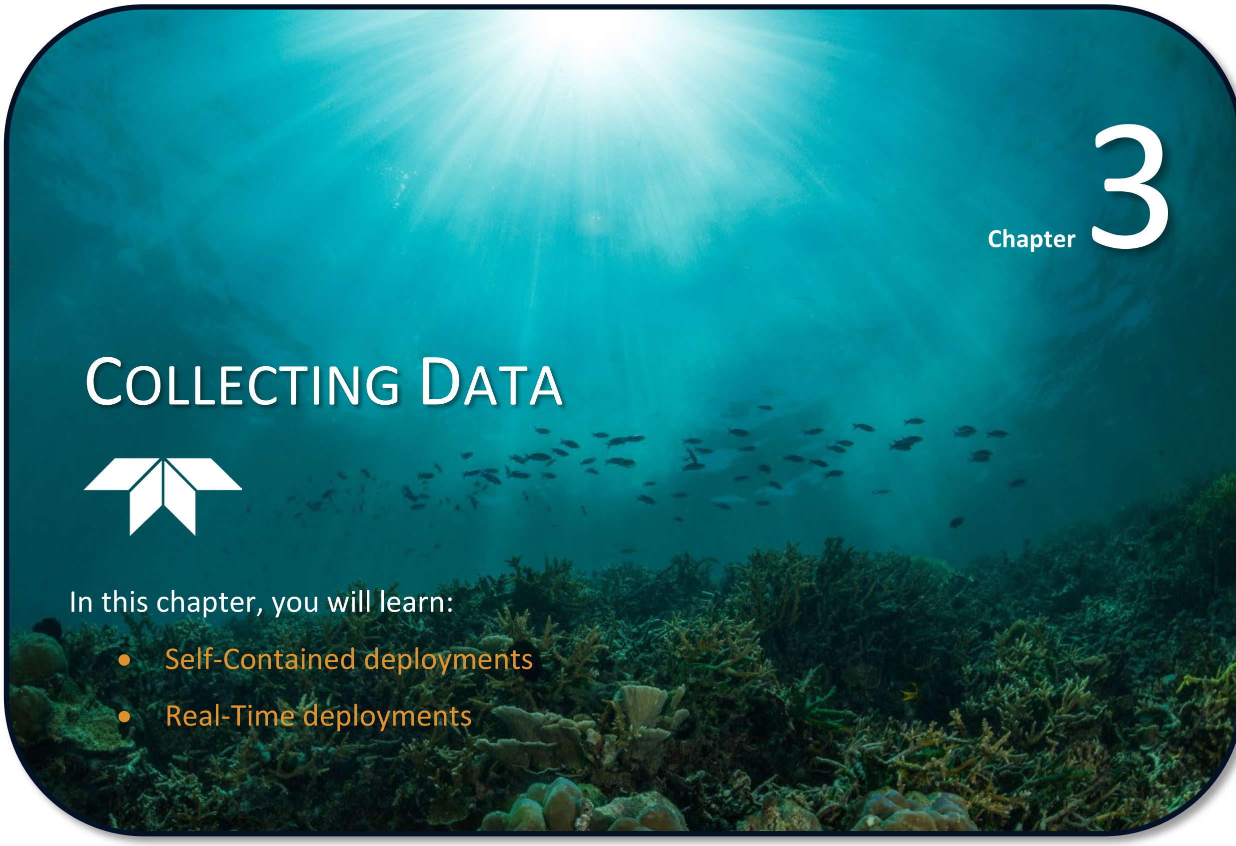


Figure 40. Transducer Misalignment Reference Points

The alignment of the transducer installation holes on the Mariner Adapter Plate to the centerline of the transducer is within 0.15 degrees. We recommend you choose a bolt (or stud) that fills the installation holes as close as possible to limit any additional misalignment.



Chapter 3

COLLECTING DATA

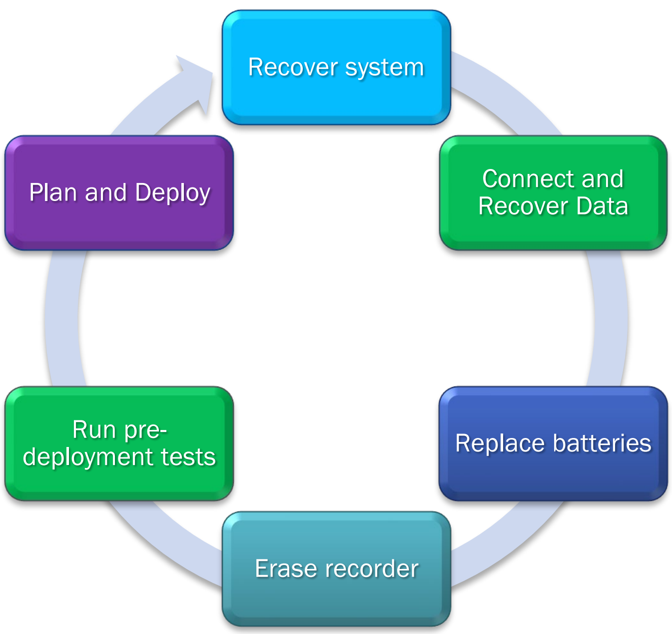
In this chapter, you will learn:

- Self-Contained deployments
- Real-Time deployments

Self-Contained Deployments

The Self-Contained deployment typical turn-around involves the following tasks:

1. Recover the ADCP to the deck of the support vessel.
2. Connect to the ADCP using *TRDI Toolz*. Download the data to the laptop.
    - It is recommended that all data is downloaded and verified before the CompactFlash recorder is erased.
3. Replace the batteries.
4. Erase the CompactFlash recorder using the RE ErAsE command (this command is case sensitive).
5. Close the self-contained housing and run the pre-deployment tests.
6. Plan the deployment with *Workhorse II Plan* and redeploy the ADCP.



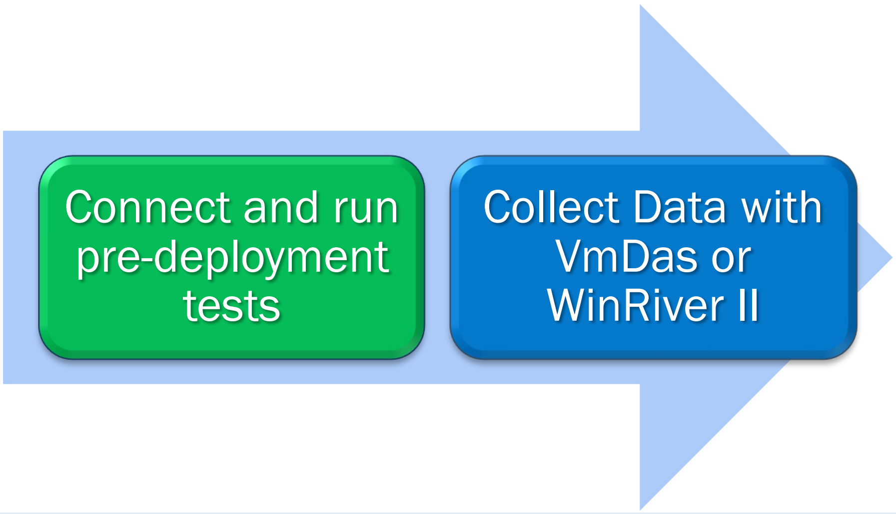
For information on Self-Contained deployments, see the Monitor/Sentinel Deployment Guide and the Workhorse II Plan help file.

Real-Time Deployments

Workhorse II deployments in real time collect, view, and process data collected using the *VmDas* or *WinRiver II* software.

The typical Direct-Reading deployment involves the following tasks:

1. Connect to the ADCP using *TRDI Toolz*. Use *TRDI Toolz* to run the pre-deployment tests.
2. Use *VmDas* or *WinRiver II* to collect data.

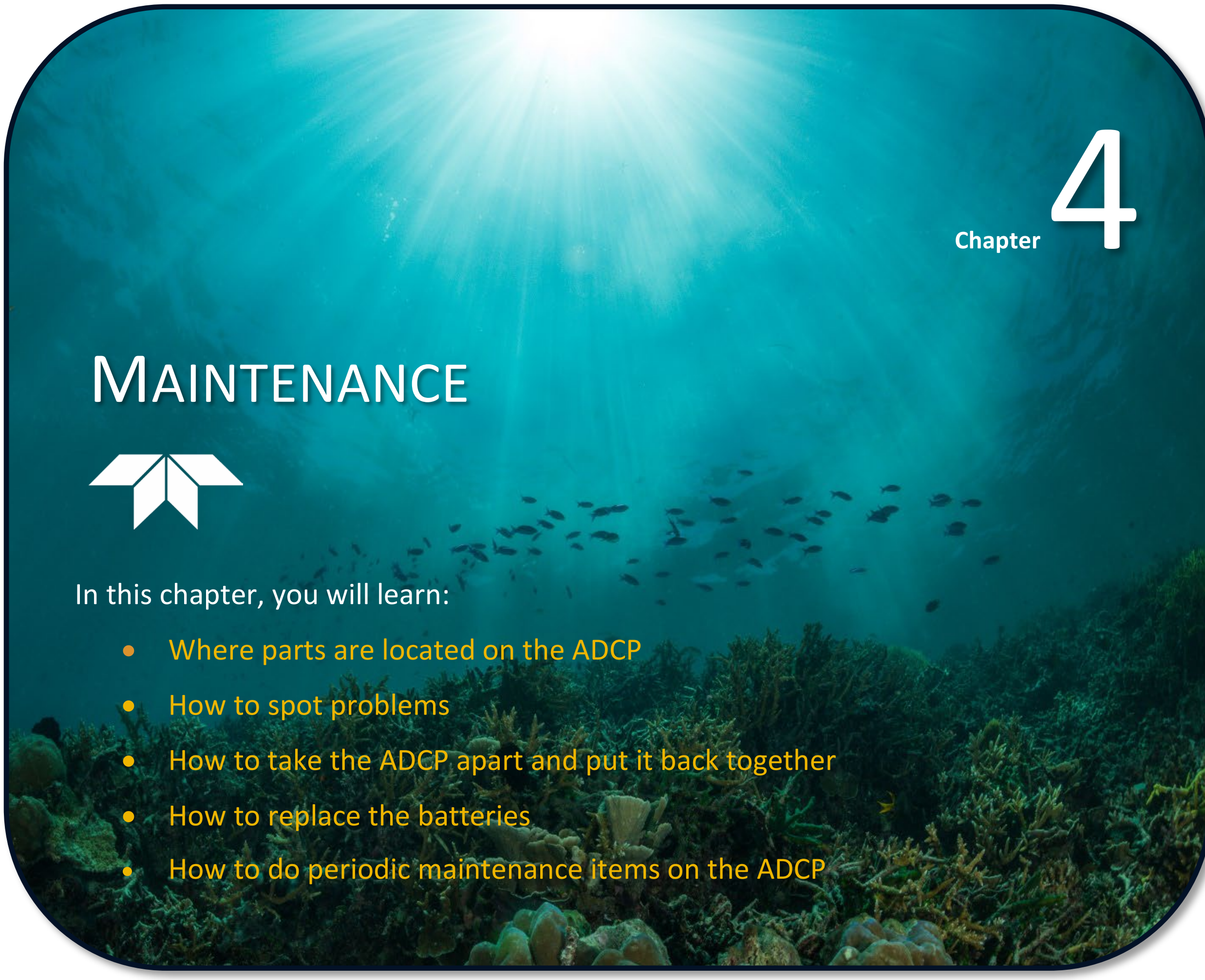


All real-time data is collected, viewed, processed, and played back using *VmDas* or *WinRiver II*. No data is recorded to the Workhorse II internal recorder. Data is recorded to the computer folder selected in VmDas or WinRiver II.

See the Mariner Deployment Guide.

For information on *VmDas* or *WinRiver II*, clicking Help in the software will open the software user's guide.

NOTES



Chapter 4

MAINTENANCE

In this chapter, you will learn:

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

Parts Location Drawings

This section is a visual overview of the inside and outside parts of the Workhorse II ADCP. Use the following figures to identify the parts used on your system.

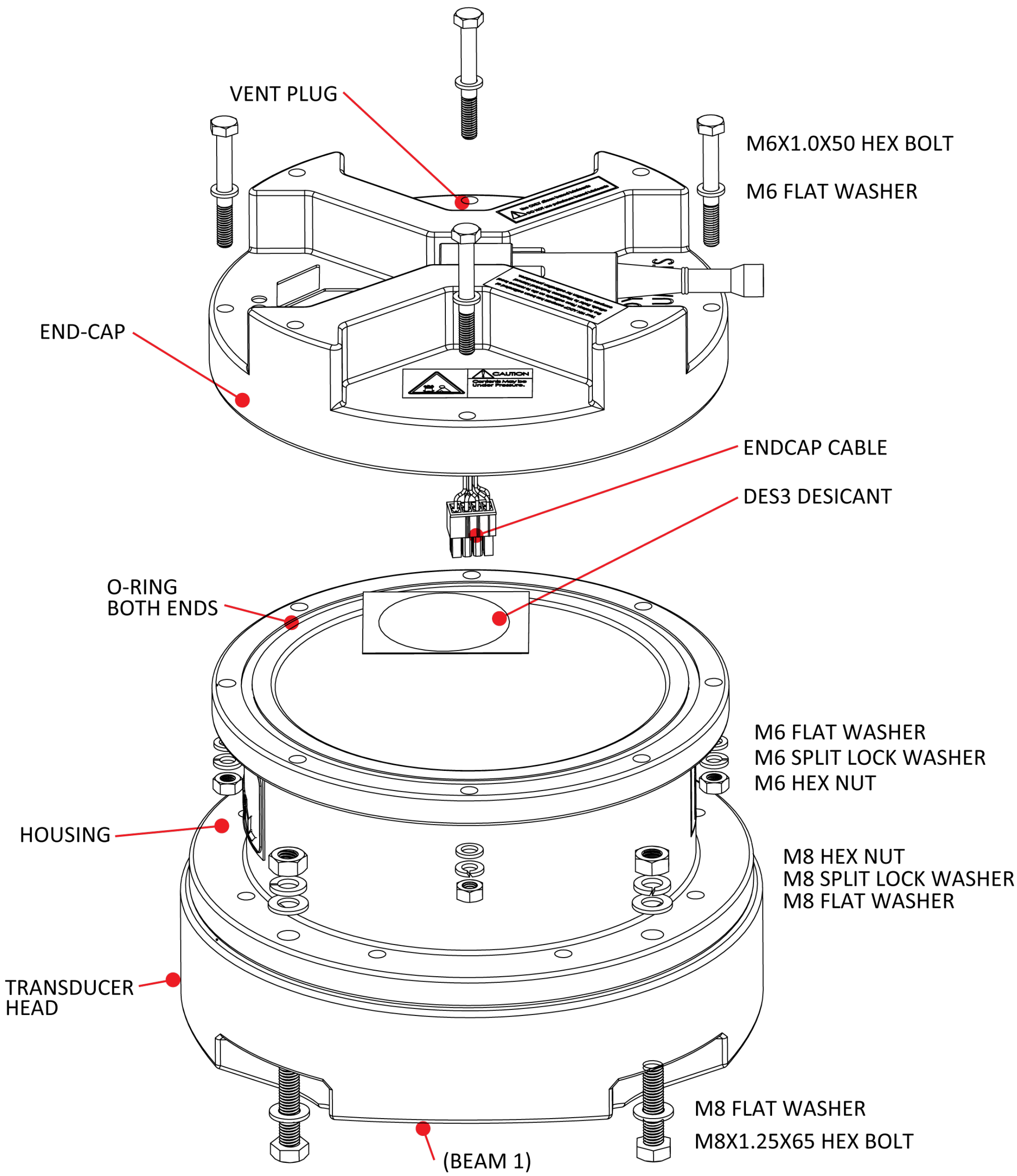


Figure 41. Mariner/Monitor Parts Location

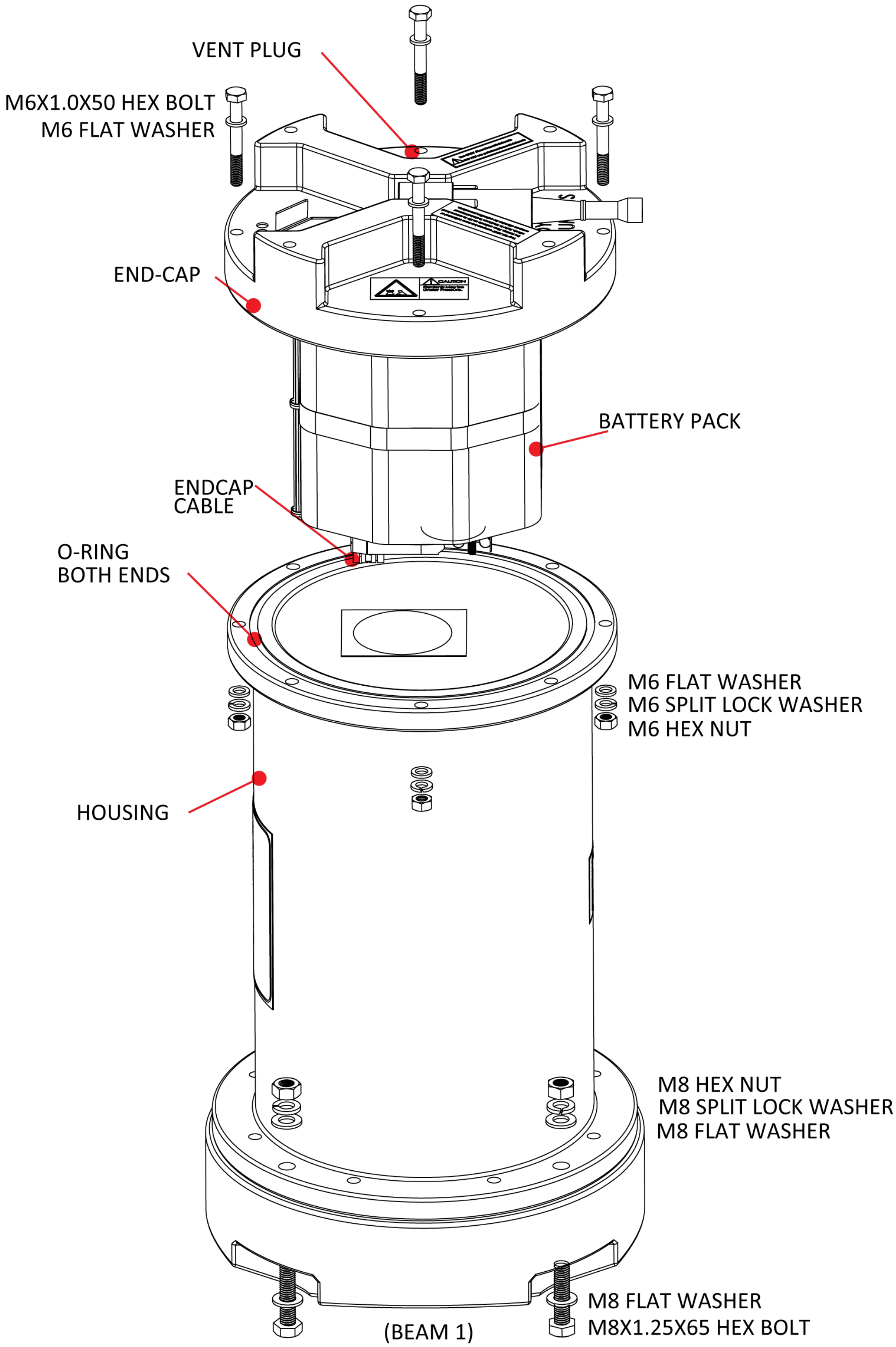


Figure 42. Sentinel Parts Location

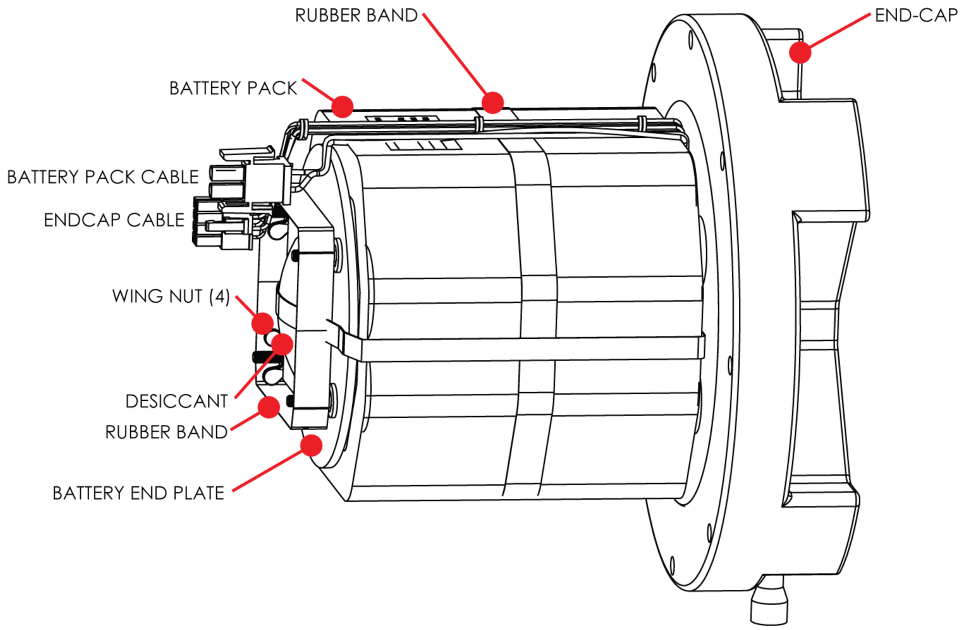


Figure 43. Sentinel End-cap and Battery Pack Parts Location

The Workhorse II Sentinel battery packs are held in place by four sets of washers, lock washers, and wing nuts. If the wing nuts are not tight, the assembly of washers and wing nut can become loose and eventually fall onto the PIO board. This has caused the PIO board to short out. Place a rubber band around the four wing nuts to help hold them in place.

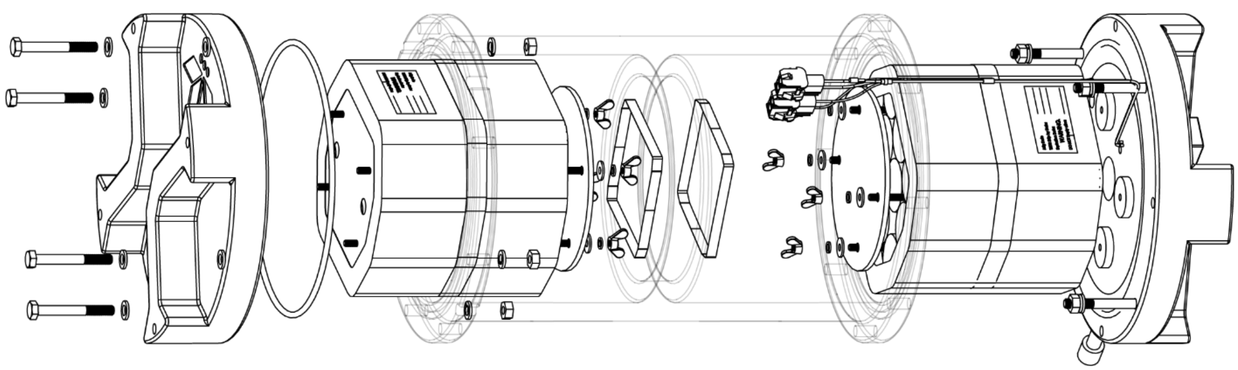


Figure 44. External Battery Pack Parts Location

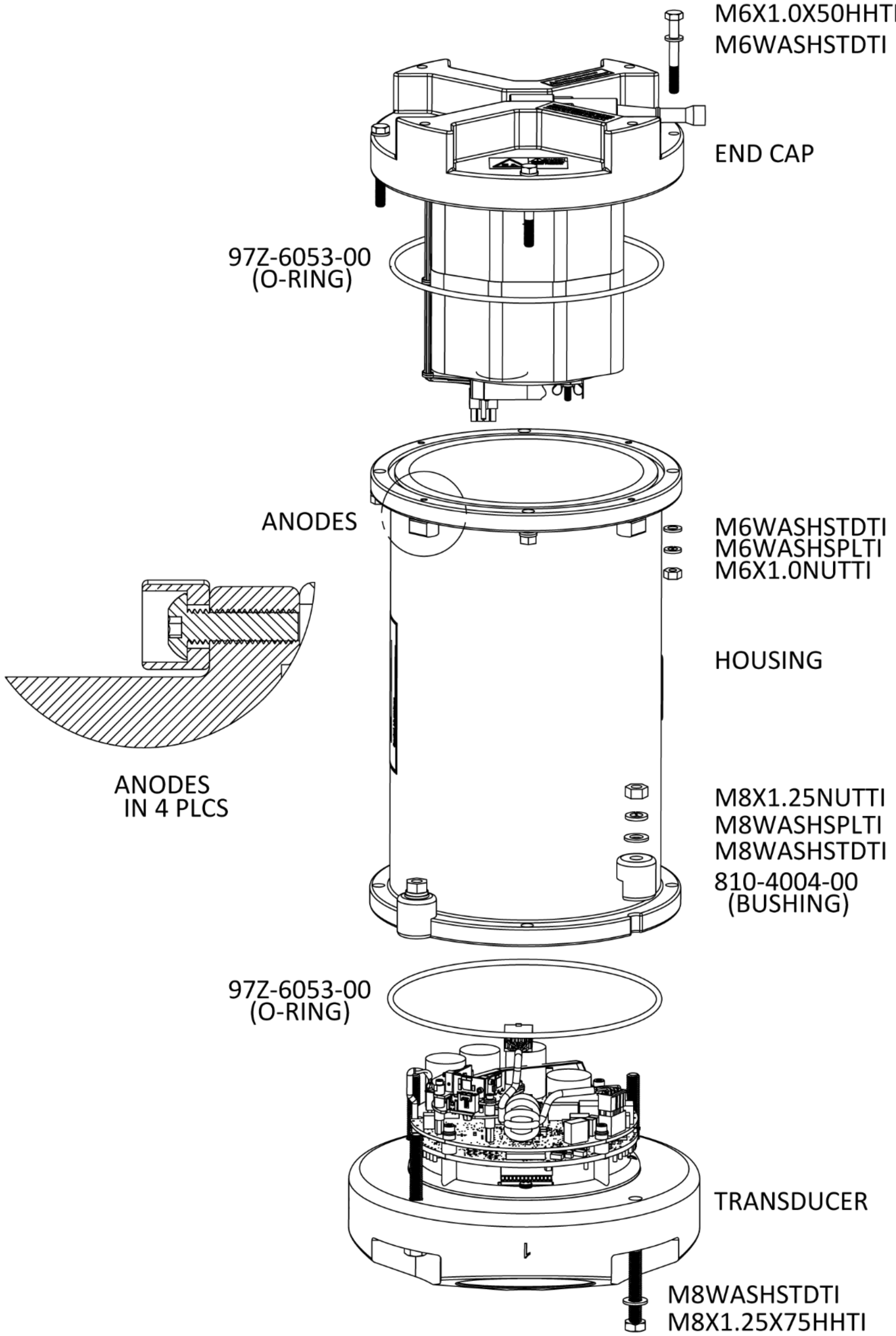


Figure 45. 500-meter Sentinel Parts Location

Maintenance Schedule

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

Calibration Items

Use the following calibration schedule:

Item	TRDI Recommended Period
Transducer Beam Angle	TRDI recommends return to TRDI every two to three years for verification of velocity accuracy
Pitch & Roll (Tilt)	TRDI recommends return every two to three years for Factory calibration
Temperature (Factory)	
Pressure Sensor (Factory)	
Heading (Factory)	
Heading (Field Pre-Deploy)	Field Compass Calibration performed prior to each deployment. Use *CompassCal* software to calibrate an internal compass.
Heading (Field Post-Deploy)	Field Compass Verification performed post each deployment. Use *Compass Post Calibration* software.

Pressure sensor drift effects will accumulate over time. TRDI recommends a factory calibration be done every two to three years. The longer you wait between factory calibrations, the more error (due to drift) you can expect to have.

For example, the pressure sensor has an initial accuracy spec of ±0.25%, and a long-term drift spec of ±0.11%. Most of the 0.11% drift will occur in the first 12 months of operation.

Maintenance Items

Inspect the ADCP to spot problems:

Item	TRDI Recommended Period
Transducer Beams	The urethane coating is important to ADCP watertight integrity. Many users are not familiar with the early signs of urethane failure. The primary damage to the urethane is from bio-fouling and long exposure to the water and sun. Damage occurs on the surface of the urethane and at the edge where the urethane bonds to the cups. Mishandling, chemicals, abrasive cleaners, and excessive depth pressures can also damage the transducer ceramics or urethane coating. Before each deployment, check the urethane coating on the transducer faces for dents, chipping, peeling, urethane shrinkage, hairline cracks and damage that may affect watertight integrity or transducer operation (see Figure 46). **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. For example, when replacing the Sentinel battery, the end-cap is removed. Replace the end-cap O-ring each time the end-cap is removed. **All O-rings should be replaced one to two years maximum.**
Housing and End Cap	Inspect for damage and replace as needed before each deployment.
Hardware (bolts, etc.)	Check all bolts, washers, and split washers for signs of corrosion before each deployment. **TRDI recommends replacement after every deployment or every year whichever is longer. Damaged hardware should never be used.**
Cables and Connectors	Check the end-cap I/O connector for cracks or bent pins (see Figure 47) before each deployment. **Replace the end-cap I/O connector every five years as a normal maintenance item.** Check the cable connectors for cracks or bent pins. Inspect the full length of the cable for cuts, nicks in the insulation, and exposed conductors before each deployment. Check the Deck Box (Mariner) connectors on the rear panel for cracks or bent pins. Repair of the Deck Box connectors should only be done by TRDI.

Figure 46. Transducer View

Figure 47. End-Cap View

Spare Parts

Periodic maintenance helps maintain the Workhorse II so it is ready for a deployment. Use the following tables if you need to order replacement parts.

Table 4: Workhorse II - Spare Parts (757K6188-00)

Part Number	Item Name	Where Used:
SPR84-1LB	Rubber Band	Battery pack to hold desiccant in place
5020	Silicone Lubricant	Housing
97Z-6052-00	O-Ring, 2-260 (200-meter housing)	
97Z-6084-00	O-RING, 2-015 .070DIAX.551 ID, EPDM, DURO 90A, VENT PLUG	
97Z-6084-01	O-RING, 3-904, .072DIAX.351 ID, EPDM, DURO90A, VENT PLUG	
M6WASHSPLTI	Washer, 6MM Split Lock, Titanium	
M6WASHSTDTI	Washer, Flat, Titanium 12.5MM OD	
M6X1.0NUTTI	Nut, Hex, Titanium 10MM	
M6X1.0X50HHTI	Screw, Hex Head, Titanium	
M8WASHSPLTI	Washer, Split Lock, Titanium	
M8WASHSTDTI	Washer, Flat, Titanium 22.9MM OD	
M8X1.25NUTTI	Nut, Hex, Titanium 13MM	
M8X1.25X65HHTI	Screw, Hex Head, Titanium Full Threads Length	
GMA-3A	Fuse, 5MM X 20MM 3R 250V	Main Electronics
DES3	Desiccant, Sealed Bag	Inside Housing
817-1067-00	Screw, Pressure Sensor	Pressure Sensor

Table 5. Replacement Kits

Part Number	Description	Where Used
757K6023-00	Workhorse II Sentinel Battery Pack Kit (includes 1 battery, desiccant, and 2 rubber bands)	Replacing the Sentinel Battery Packs Replacing the External Battery Case Packs
717-3009-00	Workhorse II Sentinel Battery Packs (10-pack)	
707-2038-12	KIT, UPGRADE, ISM, MAIN ELEC, ASSY, 1200KHZ, WH-II	Installing the Spare Boards Kit
707-2038-13	KIT, UPGRADE, ISM, MAIN ELEC, ASSY, 600KHZ, WH-II	
707-2038-14	KIT, UPGRADE, ISM, MAIN ELEC, ASSY, 300KHZ, WH-II	
757K6188-00	Workhorse II 200-meter Sentinel Spare Parts Kit	Replacement spare parts kit (see Table 4 for list of included parts.
757K6186-00	Workhorse II 200-meter Close-up kit	Includes needed hardware, housing O-ring, desiccant, and labels to seal the ADCP.

Disassembly and Assembly Procedures

This section explains how to remove and replace the end-cap or transducer head to gain access to the ADCP's electronics, batteries, and internal recorder. Read all instructions before doing the required actions.

Standard 200-meter-meter housings

- End-Cap Removal Procedures
- Transducer Head Assembly Removal
- O-ring Inspection and Replacement
- End-cap Replacement
- Transducer Head Replacement

End-Cap Removal Procedures

Caution label on End-Cap

Wear safety glasses and keep head and body clear of the end-cap while opening.

Any system that was deployed may have pressure inside the housing.

When you need access to the electronics, TRDI recommends removing the transducer head assembly (see Transducer Head Assembly Removal).

Use Parts Location Drawings for parts identification.

To remove the end-cap:

1. Dry the outside of the ADCP.
2. Disconnect the I/O cable and install the dummy plug.
3. Stand the ADCP on its transducer faces on a soft pad.
4. Inspect the housing and end cap bolts for any signs of damage such as bending, stretched bolts, crushed, or deformed bushings, etc. These signs may indicate that there is internal pressure inside the system.
5. To avoid any possible injury, it is ALWAYS recommended to vent the system:

   Use the Vent Plug to vent the system before opening the housing. Using a 7/8" socket wrench, loosen the port ½ turn and listen for airflow; if none, then open another ½ turn and listen again for airflow. Repeat until the Vent Plug is fully removed. This will ensure no internal pressure is present when removing the housing.
6. Once you are sure that there is no internal pressure, use two 10mm combination wrenches to remove the bolts from the end-cap.

   Make sure you save all hardware removed during this procedure for re-assembly.

7. Carefully pull the end-cap away from the housing until you can gain access to the connector jack on the common mode choke. Use care; the plastic mating surfaces scratch easily. Do not damage the mating surfaces.
8. Squeeze the sides of the internal I/O cable connector to release it from the common mode choke jack. Set the end-cap aside.
9. Clean the O-ring mating surfaces with a soft, lint-free cloth. Inspect the surfaces for damage (see O-ring Inspection and Replacement). Even small scratches can cause leakage around the O-ring seal.

Transducer Head Assembly Removal

When you need access to the Sentinel internal battery, remove the end-cap assembly (see End-Cap Removal Procedures).

To remove the transducer head:

1. Remove all power to the Workhorse II.
2. Remove the I/O cable and place the dummy plug on the I/O cable connector (see I/O Cable and Dummy Plug).
3. Stand the Workhorse II on its end-cap.

Wear safety glasses and keep head and body clear of the transducer while opening.

Any system that was deployed may have pressure inside the housing.

4. Inspect the transducer bolts for any signs of damage such as bending, stretched bolts, crushed or deformed bushings, etc. These signs may indicate that there is internal pressure inside the system.
5. To avoid any possible injury, it is ALWAYS recommended to vent the system:

   use the Vent Plug to vent the system before opening the housing. Using a 7/8" socket wrench, loosen the port ½ turn and listen for airflow; if none, then open another ½ turn and listen again for airflow. Repeat until the Vent Plug is fully removed. This will ensure no internal pressure is present when removing the housing.
6. Once you are sure that there is no internal pressure, use two 13mm combination wrenches to remove the bolts from the transducer.
7. Carefully lift the transducer assembly straight up and away from the housing until you can gain access to the connector jack on the common mode choke. Use care; the plastic mating surfaces scratch easily. Do not damage the mating surfaces.

   The cable attached to the end cap is only long enough to disconnect the internal I/O cable. There is NOT enough cable to set the transducer down next to the Housing Assembly.
8. Squeeze the sides of the internal I/O cable connector to release it from the common mode choke jack. Set the end-cap assembly aside. Set the transducer assembly (transducer face down) on a soft pad.
9. Clean the O-ring mating surfaces with a soft, lint-free cloth. Inspect the surfaces for damage (see O-ring Inspection and Replacement).
10. When you are ready to re-assemble the Workhorse II, see Workhorse II Re-assembly.

Workhorse II Re-assembly

To replace the end-cap and transducer head, proceed as follows. Use Parts Location Drawings for parts identification.

1. If you are sealing the Workhorse II for a deployment, be sure you have done all appropriate maintenance items (see Sealing the Workhorse II for a Deployment).
2. Make sure all printed circuit boards, spacers, cables, and screws have been installed.
3. Install two fresh bags of desiccant just before closing the Workhorse II (see Desiccant Bags).

O-ring Inspection and Replacement

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

200-meter housings

- Transducer assembly, face, 2-260
- End-cap assembly, face, 2-260

500-meter housing

- Transducer assembly, face, 2-261
- End-cap assembly, face, 2-261

Vent Plug

- 97Z-6084-00 O-RING, 2-015, .070DIAX .551 ID, EPDM, DURO 90A, VENT PLUG
- 97Z-6084-01 O-RING, 3-904, .072DIAX .351 ID, EPDM, DURO90A, VENT PLUG

TRDI strongly recommends replacing these O-rings whenever you disassemble the Workhorse II. Inspecting and replacing the O-rings should be the last maintenance task done before sealing the Workhorse II.

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

To replace the O-Ring:

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

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

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

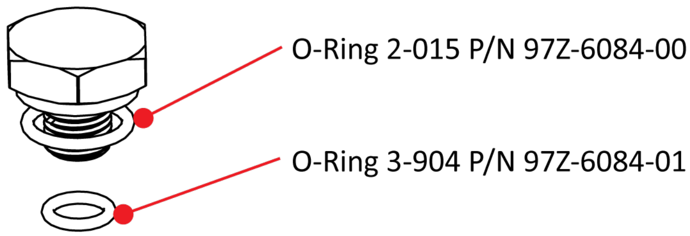
   Check the O-ring groove thoroughly. Any foreign matter in the O-ring groove will cause the ADCP to flood.

3. If a scratch is on the plastic housing flange O-ring groove, it may be gently sanded using 600-grit (wet) sandpaper. Use care not to cause further damage.

4. Lubricate the O-ring with a thin coat of silicone lubricant (**Table 4**, item 5). Apply the lubricant using latex gloves. Do not let loose fibers or lint stick to the O-ring. Fibers can provide a leakage path.

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

5. Lubricate and inspect the Vent Plug O-rings. Place the lower Vent Plug O-ring so that it rests on the bottom of the vent plug hole. Check the face Vent Plug O-ring is in the groove on the plug.
6. Install the Vent plug until "finger-tight."
7. Using a 7/8" socket wrench, tighten the Vent Plug to the recommended torque value of 6.78 Newton-meters (60 pound-inches).



Tighten the Vent Plug to the recommended torque value of 6.8 Newton-meters (60 pound-inches).

End-Cap Replacement

To replace the end-cap:

1. Stand the Workhorse II on its transducer face on a soft pad.
2. Inspect, clean, and lubricate the O-ring on the housing (see O-ring Inspection and Replacement). Apply a very thin coat of silicone lube on the O-ring.

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

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

3. Connect the internal I/O connector to the plug on the common mode choke.
4. Place the end-cap on the housing, aligning the mating holes and the beam 3 number embossed on the end-cap with the beam 3 number embossed on the transducer head. When mating the end-cap with the housing flange, try to apply equal pressure to all parts of the O-rings. Make sure the face O-ring remains in its retaining groove.

Check that no wires or any other object is pinched between the end-cap and the housing. Use rubber bands to hold the wiring in place as necessary. If the O-ring is not in the groove or if a wire or other object is pinched, the ADCP will flood.

5. Examine the titanium end-cap assembly nuts, bolts, and washers (6-mm) for corrosion; replace if necessary. The Parts Location Drawings shows the assembly order of the end-cap mounting hardware. All the hardware items are needed to seal the Workhorse II properly.

6. Install all four sets of hardware until "finger-tight."
7. Using two 10mm combination wrenches, Ttghten the bolts in small increments in a "cross" pattern until the split washer flattens out, and then tighten each bolt ¼ turn more to compress the face seal O-ring evenly. Tighten the bolts to the recommended torque value of 5.6 Newton-meters (50 pound-inches).

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

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

> The recommended torque value for the end-cap 6-mm bolts is 5.6 Newton-meters (50 pound-inches).

Transducer Head Assembly Replacement

To replace the transducer head:

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

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

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

3. Connect the internal I/O connector to the plug on the common mode choke.
4. Gently lower the transducer head/electronics assembly into the housing, aligning the mating holes and the beam 3 number embossed on the transducer head with the beam 3 number embossed on the end-cap. When mating the housing with the transducer head flange try to apply equal pressure to all parts of the O-ring. Make sure the face O-ring remains in the retaining groove.

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

5. Examine the titanium transducer assembly nuts, bolts, and washers (8-mm) for corrosion; replace if necessary. The Parts Location Drawings shows the assembly order of the transducer mounting hardware. All hardware items are needed to seal the Workhorse II properly.
6. Install all four sets of hardware until "finger tight."
7. Using two 13mm combination wrenches, tighten the bolts in small increments in a "cross" pattern until the split washer flattens out, and then tighten each bolt ¼ turn more to compress the face seal O-ring evenly. Tighten the bolts to the recommended torque value of 9.6 Newton-meters (85 pound-inches). Do not deform the plastic bushings.

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

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

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

Replacing the Sentinel Battery Packs

The Sentinel system uses battery packs to provide power. Batteries should be replaced when the voltage falls below 30 VDC (measured across the battery connector).

Battery replacement induces both single and double cycle compass errors. The compass accuracy should be verified after replacing the battery pack. The compass does not have to be recalibrated if the compass verification passes specification.

These compass effects can be avoided by using an external battery pack. The external battery housing holds two batteries and can easily be replaced on-site. If properly used, no compass calibration will be required. The external battery pack provides an option for extended ADCP deployments.

Workhorse II Sentinel batteries are shipped inside the ADCP but not connected. Connect the battery and seal the ADCP before deployment.

To replace the battery pack:

1. Remove the end-cap (see End-Cap Removal Procedures).
2. Disconnect the battery cable going to the common mode choke.
3. Remove the four wing nuts, lock washers, and washers holding the battery pack onto the posts (**Figure 43**).
4. Remove the support plate.
5. Slide out the used battery pack.
6. Use the large rubber bands (supplied with each new pack) to hold the cables and desiccant in place.
7. Slide a new battery pack onto the four posts. Make sure the I/O cable is not pinched by the battery pack.

8. Test the battery pack voltage by measuring across the battery connector. The voltage should be +42 VDC for a new battery pack.

> If the battery pack shorts out, it will blow a protective fuse inside the battery pack. The battery pack is then open and will read as zero volts DC.

9. Position the support plate over the four posts.
10. Place a flat washer, lock washer, and wing nut on each of the four posts. Tighten the wing nuts firmly to hold the battery in place.
11. Place a battery pack rubber band (two spare rubber bands are provided with each new battery) around all four wing nuts. This will prevent the wing nuts from backing off the post.

> The Workhorse II Sentinel battery packs are held in place by four sets of washers, lock washers, and wing nuts. If the wing nuts are not tight, the assembly of washers and wing nut can become loose and eventually fall onto the PIO board. This has caused the PIO board to short out.

12. Install the desiccant under the rubber bands (see Replacing the Desiccant Bags).
13. Connect the battery cable going to the PIO board.
14. Install the end-cap (see End-cap Replacement).
15. Align the compass (see Compass Calibration).

Replacing the External Battery Case Packs

The external battery case holds two battery packs to provide power. Batteries should be replaced when the voltage falls below +30 VDC (measured across the battery connector). To replace the battery packs, do the following steps.

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

To replace the external battery case battery packs:

1. Remove one end-cap from the external battery pack (see **Figure 44**).
2. Place the external battery case on its side and carefully pull out the battery pack (attached to the end-cap).
3. Disconnect the battery power cable from the wiring harness.
4. Remove the four wing nuts, lock washers, and washers holding the battery pack onto the posts (see **Figure 43**).
5. Remove the support plate.
6. Slide out the used battery pack.
7. Slide a new battery pack onto the four posts. Make sure the wiring harness is not pinched by the battery pack. Use the large rubber bands (supplied with each new pack) to hold the cables in place.
8. Position the support plate over the four posts.
9. Place a flat washer, lock washer, and wing nut on each of the four posts. Tighten the nuts to hold the battery in place.
10. Test the battery pack voltage by measuring across the battery connector. The voltage should be +42 VDC for a new battery pack.

    > If the battery pack shorts out, it will blow a protective fuse inside the battery pack. The battery pack is then open and will read as zero volts DC.

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

Workhorse II Lithium Battery Packs

The optional Workhorse II Lithium Battery Packs can be used interchangeably in Workhorse II Sentinels. This battery pack is assembled using lithium battery cells that provide 34 VDC with a capacity of approximately 1650 Wh. The battery includes a safety circuit that protects the battery and users against short circuits and provides users the ability to test the pack (see Testing the Lithium Battery Pack). The circuit also turns the battery off at its end of life before the battery fully discharges. This happens when about 97% of the battery's capacity is depleted.

Follow the instructions provided in Replacing the Sentinel Battery Packs when replacing the Lithium battery pack in a Sentinel ADCP or the external battery case. The Lithium battery will fit on the posts the same as the alkaline battery.

Disposal of used battery packs should be done in accordance with applicable regulations, which vary from country to country. In most countries, trashing of used batteries is forbidden and disposal can be done through non-profit organizations mandated by local authorities or organized by professionals.

Figure 48. Workhorse II Lithium Battery Pack

The optional Lithium battery packs are restricted to Cargo Aircraft Only since 1 January 2015. Do NOT return ADCP units with the optional Lithium battery pack installed.

Power on Cycle

Workhorse II ADCPs require +20 to 50 VDC to operate. A fresh alkaline battery provides +42 VDC. The Lithium battery provides +34 VDC. The power supply or battery pack 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 ADCP. The capacitors provide a store of energy for use during transmit. The inrush current is as high as 3 Amps rms. The ADCP will draw this amperage until its capacitors are fully charged.

If the power supply or battery pack limits the current or the power drop on the cable is significant, then the power on cycle will take longer. It can take up to one minute. You do not want the power to shut down during the inrush current draw, as this may not allow the ADCP electronics to start.

AC Power Adapter

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

The AC Adapter input voltage is sufficient to override the internal Lithium battery voltage (for example, the ADCP will draw all power from the AC adapter even if the Lithium battery is installed and connected). Always use the AC adapter when testing the ADCP to conserve the battery power.

Before using the optional Lithium battery pack, always run the battery self-test. See Testing the Lithium Battery Pack for instructions.

Instruments with high inrush currents occasionally trigger the optional Lithium battery pack short circuit detection, which turns the battery off. If this happens, do the following:

- Connect the AC adapter and wait for a minute and then connect the battery pack. Once the ADCP is connected, unplug the AC adapter. The ADCP will work normally after that.

Testing the Lithium Battery Pack

The optional Lithium battery pack includes a safety circuit that turns the battery off at its end of life, before the battery fully discharges. This happens when about 97% of the battery's capacity is depleted. The circuit also protects the battery and users against short circuits and provides users the ability to test the pack. When the battery detects a short circuit, it waits about 300 us, and then it turns itself off. A red LED on the circuit indicates when it detects a short. The circuit monitors the load across the battery and as soon as the load is removed, it displays the results of its self-test.

Before installing the Lithium battery pack, run the self-test by shorting the battery's pins with a bent paperclip. The LED display lasts approximately 10 seconds and indicates the battery status:

- A continuous green LED tells you the battery is new.
- A flashing green LED tells you the battery has been used but can still power an ADCP.
- A continuous red LED tells you the battery has been disconnected at its end of life and cannot be used any more.
- If there is no LED light at all the circuit is defective, and you should not use the battery.

You should run the self-test when you receive new lithium battery packs. This way, there is time to replace defective batteries before you deploy. You should also run the self-test just before installing the battery.

Calibrating the Compass

The main reason for compass calibration is battery replacement. Each new battery carries a different magnetic signature. The compass calibration algorithm corrects for the distortions caused by the battery to give you an accurate measurement.

To achieve the best possible field calibration of the compass, the compass calibration should be performed:

- In a "magnetically clean" environment, i.e. in an area free from stray magnetic fields (electronics, power lines, etc.) and magnetic materials such as iron.
- As close as possible to the actual deployment site (so that during calibration the instrument is measuring a magnetic field intensity and dip angle that are as close as possible to the as-deployed environment)
- With a large variety of instrument orientations (ideally tilting the instrument by 30 degrees or more during orientation).
- TRDI recommends that if you are having trouble calibrating the Workhorse II ADCP compass that you move the system and/or ensure the area around the system is clear of electrical equipment and ferrous materials.

In an oil & gas environment, it is typically impossible to meet the first two requirements above. Oil fields are full of metal structures that preclude a "magnetically clean" environment. Even in standard oceanography, for example a deep-water deployment in the open ocean, it is not possible to meet both requirements because any location reasonably near the deployment site is aboard a ship, which will be a decidedly magnetically dirty environment. Therefore, the customer typically must choose between calibrating a long way away from the deployment site or use the factory default calibration.

Preparing for Calibration

To prepare for compass calibration:

1. Protect the Workhorse surfaces from contact or abrasion during calibration. Use the transducer cover to protect the ADCP transducer faces during calibration if the calibration is in a face down orientation.
2. Compass calibration should be performed free from ambient magnetic fields. Choose a calibration location outside, away from magnetic materials. Nearby steel, iron, magnets, and other magnetic fields will degrade the calibration and accuracy and will provide a poor calibration.
3. Use a wood or plastic test platform at least 1 meter (~3 feet) high to move away from metal under the ground.

   If you are using a calibration stand, place the ADCP in the stand in the same orientation as it will be deployed.

The WH-V is shown with a Teledyne RD Instruments
Workhorse Sentinel ADCP loaded for UPWARD Profile Calibration (center)
and loaded for a DOWNWARD Looking Profile Calibration (right).

Compass calibration stands are not required to calibrate the Workhorse II compass, but they do make it much easier and increase the calibration accuracy.

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

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

4. Connect the Workhorse II as shown in Setting up the Workhorse II System.

Compass Calibration

To calibrate the internal compass:

1. Start the *ISM Compass Calibration* software.
2. Set up the communication parameters between the *Compass Calibration* software and the ADCP by clicking on the **Comm. Port** button.
3. For the **Break Type**, select **Soft**.

> Communication errors may occur during calibration when using a slow communication Baud rate. If you receive a *Failed to get calibration data…* message, try increasing the Baud rate (115200 Baud is recommended).
>
> The Workhorse II uses a Soft break for the compass calibration.

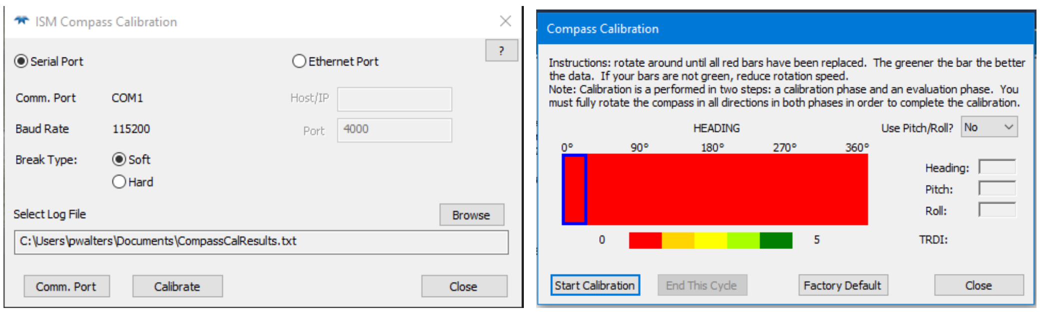


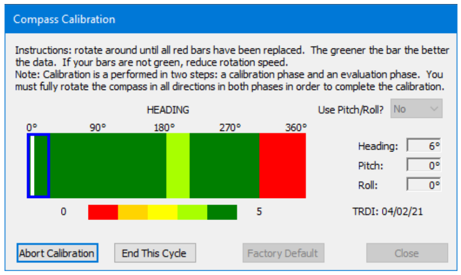
Figure 49. Compass Calibration

4. Click the **Calibrate** button.
5. Select **Use Pitch/Roll?**
   - Select **No**. This calibration requires two rotations (one for calibration and one for verification).
   - Select **Yes**. This calibration requires eight rotations (four for calibration and four for verification).

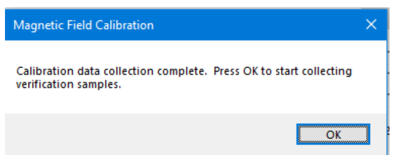
> TRDI recommends calibrating with a large variety of instrument orientations (ideally tilting the instrument by 30 degrees or more during orientation).

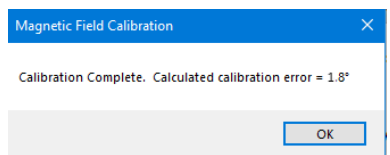
6. Click the **Start Calibration** button.

7. As you rotate the Workhorse II, the bars will change color. The Blue bar indicates where you are in the rotations.
    - Green – Good
    - Light Green – Acceptable
    - Yellow – Within parameters (one or two yellow bars for the entire rotation is OK)
    - Orange – Unacceptable - Rotate slower!
    - Red – Not measured



8. When the first rotation(s) are complete, click **OK** on the message box to continue with the verification samples.





9. When the second rotation(s) are complete, click **OK** on the message box. The calibration error should be less than 2 degrees.

Stability of the instrument during the calibration process, as well as a non-magnetic calibration site is essential to getting the lowest overall error value.

Compass Post Calibration

Compass post calibration corrects for heading errors due to hard and soft iron effects in the Workhorse reference frame during the deployment. Often post calibration will provide results more reliable than when only a pre-deployment calibration is performed.

Some example scenarios where the post calibration is useful:

- The Workhorse is installed on a mooring and rotates freely sampling the magnetic environment throughout the deployment.
- The magnetic properties of the installation changed after the pre-deployment calibration. A battery pack was added, or the Workhorse was installed in a mounting frame constructed of a ferrous material.
- The Workhorse was subject to magnetic interference during the pre-deployment calibration.

Post calibration will not be effective if:

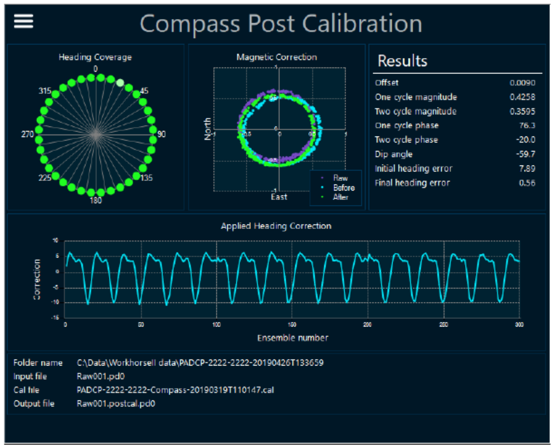
- The magnetic interference is not in the Workhorse reference frame. The Workhorse is deployed adjacent to a large metal structure like a bridge or ship for example.
- The magnetic properties change over the deployment.

Heading Coverage: Green indicates heading data was collected. Light green indicates some heading data was collected. Missing circles indicates the ADCP did not collect heading data for that direction.

Magnetic Correction: The Before series (shown in cyan) is the Raw data (shown in purple) with the existing magnetic correction applied, the After series (shown in green) is the Raw data with the post-calibration correction applied.

Example Postcal.txt file:

```
Date: 10/20/2021 3:05 PM
Offset: 9.02e-003
One cycle: 4.26e-001
Two Cycle: 3.60e-001
One cycle phase: -76.3
Two cycle phase: -20.0
Dip angle: -59.7
Initial heading error: 7.9°
New heading error: 0.56°
Use Post-cal: true
```



The *filename.pd0* data file and the *filename.cal* calibration file must be in the same folder.

Post Calibration will create the *filename.postcal.txt* and *filename.postcal.pd0* files.

The original raw data is not changed. Use the *filename.postcal.pd0* file to view the data with the post compass calibration correction applied.

The **Offset** is the amount by which the calibrated circle must be moved to be centered on zero.

The **One-Cycle Magnitude** and **Phase** are the RMS hard iron correction. That is, how big is the circle and at what angle is its origin.

The **Two-Cycle Magnitude** and **Phase** are the RMS soft iron correction. That is, how round (non-elliptical) is the circle and at what angle is its origin.

Dip angle is the angle made with the horizontal by the Earth's magnetic field lines.

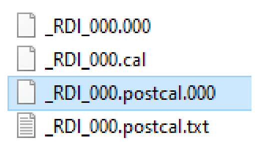
Initial Heading Error is the compass error before the post calibration is applied.

Final Heading Error is the compass error after the post calibration is applied.

To post calibrate the data:

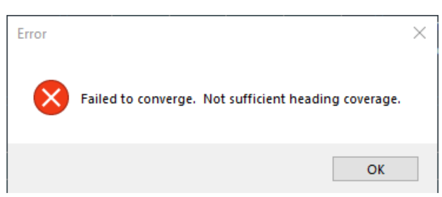
1. Use *TRDI Toolz* to download the data from the CompactFlash recorder. For example, the pd0 data file is named *_RDI_000.000* and the *_RDI_000.cal* is the post calibration file and both files are downloaded to the same folder.

2. Start the *Compass Post Calibration* software and click the **Menu** button to select the PD0 data file (*.000).
3. *Compass Post Calibration* will create the *filename.postcal.txt* and *filename.postcal.000* files. The original raw data is not changed. Use the *filename.postcal.000* file to view the data with the post compass calibration correction applied.



The *.cal* file is created during data collection and is recorded to the CompactFlash recorder with the *.000 pd0 data file.

Post calibration relies upon the instrument moving sufficiently the during the deployment to collect "raw magnetometer" data for the heading coverage. If the *.cal file did not have sufficient heading coverage, then the post calibration will fail to converge.



Mariner Adapter Plate

The adapter plate helps mount the Mariner transducer head to a vessel. See the Outline Installation Drawings for dimensions. The following procedure explains how to install and remove the Adapter Plate on a Workhorse II Mariner ADCP.

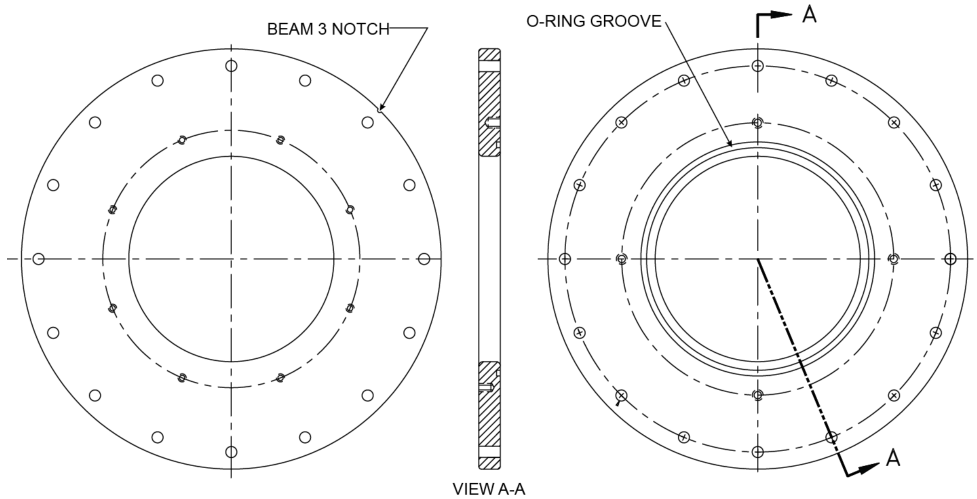


Figure 50. Mariner Adapter Plate

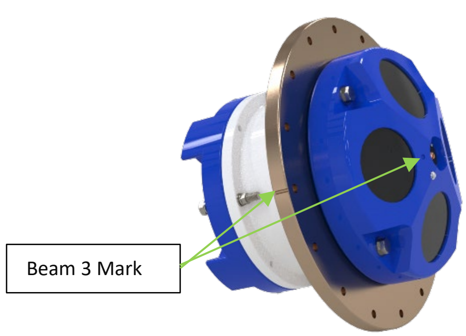
Installing the Adapter Plate

To install the adapter plate:

1. Remove the Transducer Assembly (see Transducer Head Assembly Removal).
2. Inspect and clean the O-ring groove of the Housing Assembly.
3. Inspect, clean, and lubricate the O-ring (2-260) on the Housing Assembly where the Transducer Assembly was just mounted. Apply a very thin coat of silicone lube on the O-ring.

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

4. Inspect and clean the Adapter Plate. Be sure no scratches, dents, or foreign matter is around the area that will be contact with the O-ring on the Housing Assembly.
5. Place the adapter plate on the Housing Assembly, ensuring that the O-ring is not pinched or damaged. Rotate the plate such that the Beam 3 alignment notch in the plate is in alignment with the beam 3 mark on the transducer.



Check that no wires or any other object is pinched between the adapter plate and the housing. Use rubber bands to hold the wiring in place as necessary. If the O-ring is not in the groove or if a wire or other object is pinched, the ADCP will flood.

6. Using four of the titanium 8-mm bolts supplied in the Adapter Plate Kit, secure the Adapter Plate to the Housing Assembly. Install the split lock washer next to the head of the bolt followed by a flat washer before installing the 8-mm bolts.
7. Install all four sets of hardware until "finger-tight."
8. Tighten the bolts in small increments in a "cross" pattern until the split washer flattens out, and then tighten each bolt ¼ turn more to compress the O-ring evenly. Tighten the bolts to the recommended torque value of 9.6 Newton-meters (85 pound-inches).

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

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

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

9. Install a new desiccant bag from the Adapter Plate Kit into the Housing Assembly.
10. Inspect and clean the O-ring groove of the Adapter Plate.
11. Inspect, clean, and lubricate the O-ring (2-260) from the Adapter Plate Kit and set this O-ring into the groove on the Adapter Plate.
12. Connect the cable from the end cap assembly to the Power I/O board on the Transducer Assembly.
13. Place the Transducer Assembly onto the Adapter Plate, ensuring that the O-ring is not pinched or damaged. Rotate the Transducer Assembly such that the beam-3 mark is aligned with both the alignment notch in the Adapter Plate and the beam-3 arrow on the end cap.

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

14. Using the remaining four of the titanium 8-mm bolts supplied in the Adapter Plate Kit, secure the Transducer Assembly to the Housing Assembly. You should install the split lock washer next to the head of the bolt followed by a flat washer before installing the 8-mm bolts.
15. Install all four sets of hardware until "finger-tight."
16. Tighten the bolts in small increments in a "cross" pattern until the split washer flattens out, and then tighten each bolt ¼ turn more to compress the O-ring evenly. Tighten the bolts to the recommended torque value of 9.6 Newton-meters (85 pound-inches).

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

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

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

Removing the Adapter Plate

To remove the adapter plate:

1. Remove the Transducer Assembly (see Transducer Head Assembly Removal).
2. Remove the four titanium 8-mm bolts that secure the Adapter Plate to the Housing Assembly.
3. Separate the Adapter Plate from the Housing Assembly.
4. Install the Transducer Assembly (see Transducer Head Assembly Replacement).

Periodic Maintenance Items

Replacing the Desiccant Bags

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

The average dry weight of a new desiccant bag is 7.2 grams ((5%). The weight increases to 8.4 to 9 grams for a "used" desiccant bag. Used desiccant bags may be dried at 250° for 14 hours. As a minimum, replace the desiccant bags (**Table 4**) whenever you are preparing to deploy or store the Workhorse II for an extended time.

> Do not open the desiccant bag. Contact with the silica gel can cause nose, throat, and skin irritation.
>
> Do not puncture or tear the desiccant bag. Do not use desiccant bags that are torn or open.

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

To replace the desiccant:

1. Remove the transducer head (see Transducer Head Assembly Removal).
2. Remove the new desiccant bags from the airtight aluminum bag.
3. Remove the old desiccant bags and install two new ones. For Monitor and Mariner systems, place the desiccant bags (**Table 4**) between the PIO board and the end-cap. For Sentinel systems, place the desiccant under one of the rubber bands on the battery pack.

4. Install the transducer head (see Transducer Head Assembly Replacement).

Cleaning the Thermistor Cover

To respond quickly to changes in the water temperature, water must be able to flow over the sensor. Do not block the sensor or paint over it with antifouling paint. Remove any biofouling as soon as possible.

> The Thermistor is embedded in the transducer head. The sensor is under a titanium cover that is highly resistant to corrosion.

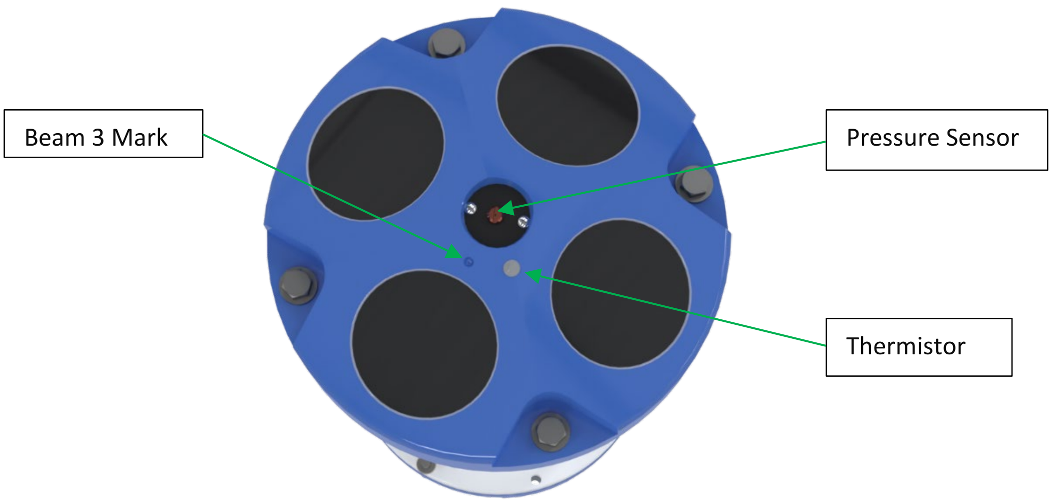


Figure 51. Thermistor and Pressure Sensor

Cleaning the Pressure Sensor Port

To read the water pressure, water must be able to flow through the copper screw on the pressure sensor. The tiny hole in the copper screw may at times be blocked. Use the following procedure and **Figure 51** to clean the screw.

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

To clean the pressure sensor port:

1. Place the ADCP on its' end-cap. Use a soft pad to protect the ADCP.
2. Use a straight-slot screwdriver to remove the copper pressure sensor port screw.
3. Gently clean out the hole in the copper screw with a needle. If the hole becomes enlarged or the screw is corroded, replace the screw. A replacement copper screw is included in the spare parts kit (part number 817-1067-00).
4. Install the copper screw. Tighten the screw "finger tight" (2 in/lbs). Do not over tighten the screw or you may strip the threads on the plastic cover disc. If this happens, return the ADCP to TRDI for repair.

Formatting the CompactFlash Memory Card

The CompactFlash Memory Card (Sentinel only) should be formatted before a deployment.

To format the recorder:

1. Start *TRDI Toolz*.
2. To recover data, leave the card in the Workhorse II and use *TRDI Toolz*. Click **Tools**, **Download Data**.
3. Send the command RE ErAsE <volume label>. RE ErAsE erases and formats the CompactFlash memory card. This command *is* case sensitive. Use RE ErAsE < volume label > to assign a volume label. The default volume label is "NO NAME ".

> Once erased, data is not recoverable.
>
> Do not format or delete files from the CompactFlash card using Windows®. This may leave hidden files on the card. Always use the ADCP’s RE ErAsE command to format and delete data from the CompactFlash card recorder.
>
> A recorder card with a file count more than 50 files will cause a noticeable delay between the first ensemble and the Start Pinging (CS) command. If this delay is a concern, ensure that unwanted files are cleared before starting the deployment.
>
> The maximum memory capacity not to exceed 4GB per deployment.

Replacing the CompactFlash Recorder

The CompactFlash Card recorder is located on the Workhorse II Processor (WHP) board inside the Workhorse II ’s electronics.

To remove or install a CompactFlash card:

1. Turn off power to the Workhorse II.
2. Remove the transducer head (see Transducer Head Assembly Removal).
3. Remove the CompactFlash card by pushing the button on the side of the card slot. The card should “pop” out of the connector. If you cannot reach the release button with your finger, use a plastic pen or non-conductive tool to depress the button.
4. Install the CompactFlash card back into the card slot with the lip facing away from the transducer. If the CompactFlash card is in inserted upside down, it will not seat all the way.

> The compact flash card can be inserted upside down, and with some force the pins can be bent. Do not try to force the card into the connector. CompactFlash cards slide easily in when properly oriented.

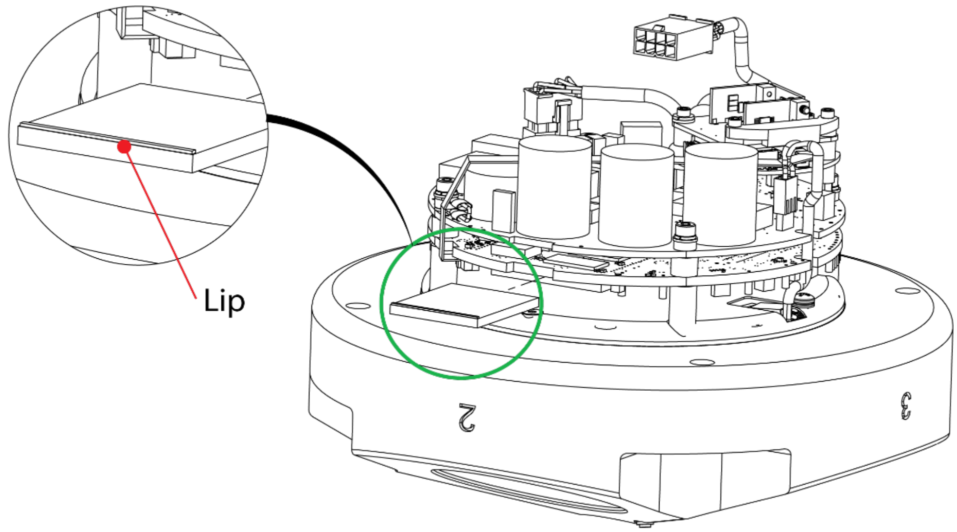


Figure 52. Installing the CompactFlash Card

5. Install the transducer head (see Transducer Head Assembly Replacement).

Zinc Anode Inspection and Replacement

> This section applies to the 500-meter Workhorse II.

The 500-meter systems have four sacrificial zinc anodes. If the Workhorse II does not have exposed bare metal, properly installed anodes help protect the system from corrosion while deployed. Read all instructions before doing the required actions.

Zinc Anode Inspection

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

To inspect the anodes:

1. Inspect the anodes on the transducer assembly, housing and end-cap for corrosion and pitting. If most of an anode still exists, you may not want to replace it.
2. Inspect the screws that fasten each anode for corrosion.
3. If you have doubts about the condition of the anodes, remove and replace the anode.

Zinc Anode Electrical Continuity Check

Check electrical continuity using a digital multi-meter (DMM). Scratch the surface of the anode with the DMM probe to make good contact if the anode is oxidized. Measure the resistance between all four housing anodes. All measurements must be less than five ohms. If not, reinstall the affected anode.

Zinc Anode Replacement

To remove and replace the zinc anode/s:

1. Remove the screw.
2. The anode may stick to the ADCP. 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.
4. Set a new anode in place and fasten with new screws.
5. Check the electrical continuity. If any measurement is greater than one ohm, reinstall the affected anode.

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

Protective Coating Inspection and Repair

This section applies to the 500-meter Workhorse II.

TRDI uses paint on the 6000 and 500-meter housings for identification and corrosion protection. For more protection, the case and the transducer assembly are first anodized per MIL-A-8625, Type 3, Class 1 and sealed with sodium dichromate. Do not damage the surface coatings when handling the ADCP.

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

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

To repair or touch up the protective paint:

1. Remove all loose paint without damaging the anodizing. Clean and prepare the damaged area using a fine-grade abrasive cloth. Feather the edges of the paint near the damaged area. Try to have a smooth transition between the paint and the damaged area. Do not sand the anodized area. If there is damage to the anodizing, return the ADCP to TRDI for repair.
2. Clean the area with alcohol. Do not touch the area after cleaning.
3. Mix the epoxy primer Part A and Part B using a 1:1 mix. Paint one coat of epoxy primer (see note below). Allow the primer to dry thoroughly before continuing.
4. Mix the colored paint using two parts color and 1 part catalyst. Paint with one coat of colored paint (see note below).

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

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

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

Colored paint Manufacturer's part numbers:
4800HS, Catalyst,
4800-19, Yellow
4800-28, Orange
Contact the paint manufacturer for preparation and application procedures for this and other paints. Contacting this company is done with the knowledge that Teledyne RD Instruments is not recommending them, but only offering this as a source for the paint.

Installing Firmware Upgrades

The firmware for Workhorse II ADCPs in located on flash RAM chips on the WHP board. Firmware upgrades can be downloaded from TRDI's software portal (https://tm-portal.force.com/TMsoftwareportal). If the firmware upgrade is not available via the web, then please contact Field Service (rdifs@teledyne.com) to request a copy.

To install a firmware update:

1. Setup the communication parameters between *TRDI Toolz* and the ADCP.
2. Wake up the ADCP by pressing the  button.
3. Click **Tools**, **Firmware Update**.
4. Unzip the downloaded file. Select the **.abs* firmware update file.

Installing Feature Upgrades

The feature upgrade installation program is used to install Bottom Tracking and Waves capabilities in an ADCP.

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.

Note for included features:

Shallow Water Bottom Track Mode 7 is included with all 1200 kHz Workhorse II ADCPs (requires Bottom Track option enabled).

High-Resolution Water Profiling Modes and **High Ping Rate Water Mode** are included with all 600 and 1200 kHz Workhorse II ADCPs.

Surface Tracking and **Lowered ADCP** (LADCP) **Water Mode 15** is included with all Workhorse II ADCPs.

To install a feature update:

1. Setup the communication parameters between *TRDI Toolz* and the ADCP.
2. Wake up the ADCP by pressing the  button.
3. Click **Tools**, **Activate Features.**
4. Unzip the file sent by Sales or Field Service. Select the **.Feature* update file.

5. Use the **OL** command (see the Workhorse II Commands and Output Data Format guide) to verify the feature upgrade has been installed.

```
>OL                             FEATURES
---------------------------------------------------------------------
Feature                                                     Installed
---------------------------------------------------------------------
BT-HA (High Accuracy 0.4%)                                      Yes
Water Profile                                                   Yes
High Resolution Water Modes                                     Yes
LADCP/Surface Track/WM15                                        Yes
Wave Gauge Acquisition                                           No
Shallow Bottom Mode                                             Yes
High Rate Pinging                                               Yes
Narrow Bandwidth only (WB1)                                      No
BT-BA (Base Accuracy 1.15%)                                      No

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

Replacing Fuses

PIO Board. There is one fuse on the PIO Board (see **Figure 56**) that protects the Workhorse II from excessive incoming power. If this fuse continues to blow, check your input power before applying power again.

To replace the fuse:

1. Turn off the power.
2. Remove the transducer head (see Transducer Head Assembly Removal).
3. The PIO board fuse is located next to the internal I/O connector. Use a small flat-blade screwdriver to open the fuse housing. Turn the end 180° (counter-clockwise) to open the fuse housing.
4. Gently pull the fuse housing out. Turn the housing to remove the fuse.
5. Check the fuse using an ohmmeter. Replace the fuse if necessary with the correct voltage and amperage fuse (included in the Spare Parts kit).
6. Install the transducer head (see Transducer Head Assembly Replacement).
7. Test the system (see Testing the Workhorse II).

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

To replace the fuse:

1. Remove one end-cap from the external battery pack (see End-Cap Removal Procedures).
2. Carefully lift out the battery pack (attached to the end-cap).
3. Check the fuse using an ohmmeter. Replace the fuse if necessary with the correct voltage and amperage fuse.
4. Install the end-cap (see End-cap Replacement).
5. Measure the voltage output of the external battery case across pin 3 (+) and pin 7 (-) on the external connector. If both battery packs are fresh, you should measure approximately +42 VDC.

Mariner Deck Box. The Deck Box back panel has three fuses.

- FUSE F1 - 5 Amp, 250 V, slow-blow, 5x20mm, clip-mounted. This fuse protects Deck Box circuits from input overload on J25 (20-60 VDC power input).
- FUSE F2 - 10 Amp, 250 V, slow-blow, 5x20mm, clip-mounted. This fuse protects Deck Box circuits from input overload on J26 (12 VDC power input).

- FUSE F3 - 5 Amp, 250 V, slow-blow, 5x20mm, clip-mounted. This fuse protects Deck Box circuits from input overload on J27 (98 - 264 VAC power input).

To replace the fuse:

1. Turn off power to the deck box.
2. Press down gently on the top edge of the fuse holder.
3. Pull the fuse holder out and down. It will extend approximately one inch. Do not attempt to remove it completely.
4. The fuse closest to the inside of the deck box is the fuse in use. Check the fuse using an ohmmeter. There may be a spare fuse attached to the holder. Verify that the spare fuse is the correct voltage and amperage before using.
5. Place the replacement fuse (and another spare as necessary) in the fuse holder.
6. Gently push the fuse holder back in place.
7. Turn on power and test the system (see Testing the Workhorse II).

Mariner Deck Box Power Supply. The Deck Box Power Supply has one fuse (F1 - 5 Amp, 250 V, fast-blow, clip-mounted). This fuse protects the Deck Box Power Supply circuits from input overload.

To replace the fuse:

1. Turn off power to the deck box.
2. Remove the Deck Box top cover.
3. Remove the fuse from the clips. Check the fuse using an ohmmeter. Replace the fuse if necessary with the correct voltage and amperage fuse.
4. Replace the Deck Box top cover.
5. Turn on power and test the system (see Testing the Workhorse II).

Changing Communications Setting

A switch on the PIO board (see **Figure 56**, page 90) changes the communication settings between RS-232 and RS-422. Your computer and the Workhorse II must both be set to the same communication setting. Use the RS-232-to-RS-422 converter if the Workhorse II is using RS-422 communications and your computer only has an RS-232 COM port.

Preventing Biofouling

This section explains how to prevent the buildup of organic sea life (biofouling) on the transducer faces. Objects deployed within about 100 meters (≈328 feet) of the surface are subject to biofouling, especially in warm water. This means Workhorse II ADCP systems are subject to biofouling. Soft-bodied organisms usually cause no problems, but barnacles can cut through the urethane transducer face causing failure to the transducer and leakage into the ADCP. Therefore, you should take steps to prevent biofouling during shallow water deployments.

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

The following options can help reduce biofouling:

- Coat the entire ADCP with antifouling paint. Make sure that the paint is applied in an even coat over the transducer faces and inductive modem (see Applying Antifouling Paints).

- ClearSignal is a clear non-toxic coating that resists biofouling because of the non-stick properties of the coating itself. For more information, see ClearSignal Biofouling Control System (clearsignalcoating.com).
- Apply Maringlide™ Anti-biofouling Protection Film to help prevent marine organisms, such as barnacles, from clinging to surfaces. By applying the film, biofouling is reduced, preventing surface damage to the transducer faces. This film is biocide-free.
  - 757K6181-00 - Kit, Antifouling Film, Maringlide (300/600 kHz)
  - 757K6183-00 - Kit, Antifouling Film, Maringlide (1200 kHz)

Antifouling Paints

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

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

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

Applying Antifouling Paints

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

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

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

1. Transducer Face Surface Preparation and high pressure painted housings - Lightly abrade the surface using Scotch Brite® to remove gloss. Thoroughly clean the areas to be painted with soapy water and dry.
2. Surface Application:
   - Mask as necessary. Do not paint over mounting hardware, pressure sensors, etc.
   - Apply an even, thin layer (0.1mm, 4mil per coat) of antifouling paint. If more than one coat is needed to reach the maximum thickness, allow each coat to dry for 16 hours.
   - When applying paint to the urethane faces, use extra caution to apply a smooth, thin coat of paint.

If the ADCP includes the optional pressure sensor, do not block the sensor port. The sensor port is a small hole in the center of the copper screw (see Pressure Sensor Maintenance). During anti-fouling paint application, tape off the screw. Once the anti-fouling paint has cured, remove the tape.

This means that the sensor port is not fully protected from bio fouling. Even though the sensor port is surrounded by the antifouling paint, bio fouling may still build up on the copper screw and eventually clog the sensor port. However, most organisms do not seem to find the small amount of unpainted surface attractive. If it is logistically possible to periodically inspect/clean the pressure sensor port, it is highly recommended. This tradeoff situation must be analyzed for individual deployments. Unfortunately, the location of the deployment site usually dictates action in this regard.

Figure 53. Antifouling Paint Applied to a Workhorse II Sentinel

Removing Biofouling

To remove foreign matter and biofouling:

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

Do not use power scrubbers, abrasive cleansers, scouring pads, high-pressure marine cleaning systems or brushes stiffer than hand cleaning brushes on the transducer faces. The urethane coating on the transducer faces could be damaged.

If there is heavy fouling or marine growth, the transducer faces may need a thorough cleaning to restore acoustic performance. Barnacles do not usually affect ADCP operation, but TRDI does recommend removal of the barnacles to prevent water leakage through the transducer face. Lime dissolving liquids such as Lime-Away® break down the shell-like parts. Scrubbing with a medium stiffness brush usually removes the soft-bodied parts. Do NOT use a brush stiffer than a hand cleaning brush. Scrubbing, alternated with soaking in Lime-Away®, effectively removes large barnacles.

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

2. Rinse with fresh water to remove soap or Lime-Away® residue.

3. Dry the transducer faces with low-pressure compressed air or soft lint-free towels.

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

Installing the Workhorse II Spare Boards Kit

This section shows how to replace the Workhorse II board stack. The Spare Boards Kit has been set up so that you will replace all the boards at once. This is done so that you do not have to risk damaging the individual boards while swapping in individual boards.

> Before handling either the Spare Board Kit or the original board set, always wear an earth-grounding static protection strap. The electronics in the Workhorse II are very sensitive to static discharge. Static discharge can cause damage that will not be seen immediately and will result in early failure of electronic components.
>
> TRDI assumes that a qualified technician or equivalent will perform all the following work.

The Spare Boards Set will allow your system to perform to the same velocity specifications as your original set. However, you must perform the Compass Calibration procedure after the installation of the batteries.

> **Do not swap individual boards between ADCPs.** Each board has individual serial numbers and calibrations that work as a set. This cannot be replicated in the field.

```
PS0                                                (example shown for a WHII board stack)
↓
Board Serial Number Data:
   57  00 00 03 8F 26 DB  23 WHP727-2022-03A
   06  00 00 03 D4 C2 F9  23 PIO727-3023-13B
   07  00 00 08 D9 09 58  09 REC727-1000-03F
↓
ISM serial number: 030000E3 23D7E86F
```

> **The receiver board is not field replaceable.** The pressure sensor factory calibration is set on this board and cannot be replicated in the field.

Remove the Original Set of Boards

To remove the original boards:

1. Remove the Transducer assembly from the pressure case. Refer to Transducer Head Assembly Removal for instructions.
2. With your earth-ground static protection strap on, use a 3mm Allen wrench to remove the four bolts that secure the original boards to the Transducer assembly.
3. Note the orientation of the transmit cable connector as it is plugged into the PIO board and to the Receiver board (see Figure 54).

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

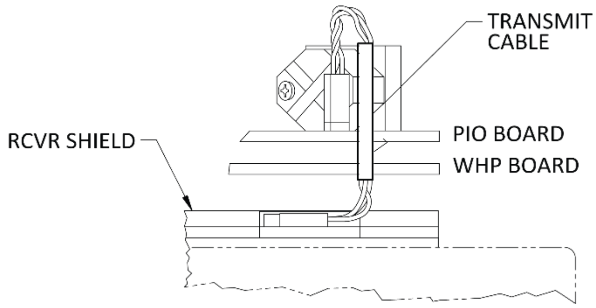


Figure 54. Transmit Cable

4. Once the transmit cable has been disconnected you may now remove the PIO and WHP boards as a set by lifting them straight up.

   These top two boards are connected to each other via connectors and will remain as one piece (see Figure 55). The WHP board connects to the Receiver board through a 26-pin header. The 26-pin header is a series of male pins. The 26-pin header may or may not stay connected to the WHP board when you remove the boards. If you see that there are male pins sticking out of the WHP board when you finish removing the board set, then the header has remained attached to the WHP board. If this happens remove it and place it into the Receiver board. To remove it, gently rock it back and forth while pulling it away from the WHP board. Once removed, align it with the connector on the Receiver board and press it into place.

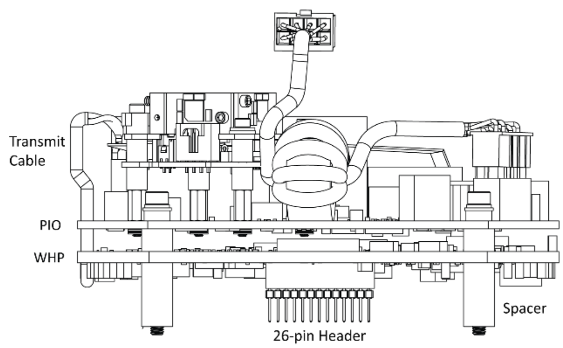


Figure 55. PC Board Connectors

5. Remove all memory cards from the original set of boards and keep.
6. Set the original board set to the side for now.

To install the Workhorse II board kit:

1. With your earth-ground static protection strap on, remove the Workhorse II Board Kit from the anti-static bag.

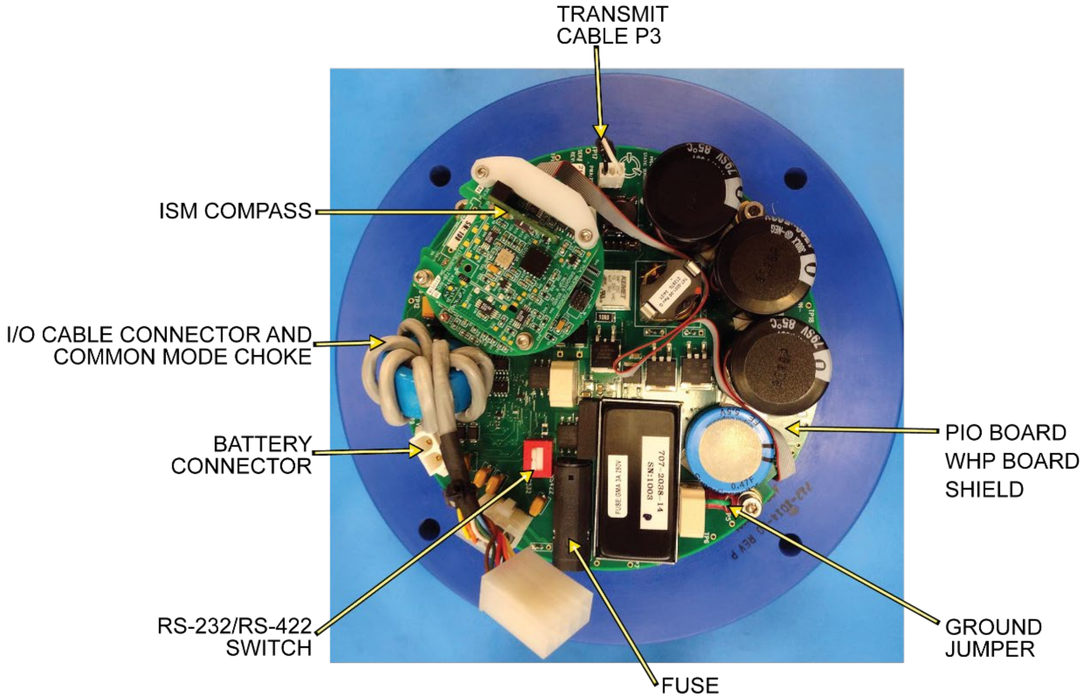


Figure 56. Workhorse II Board Stack

2. Remove the four brass thumbnuts from the M4 bolts that secure the spare board set together. You will be using these bolts to secure the boards in your system. DO NOT change the position of any of the bolts. The bolts containing the felt washers and ground jumper must remain in the same position (see Figure 57 and Figure 58).

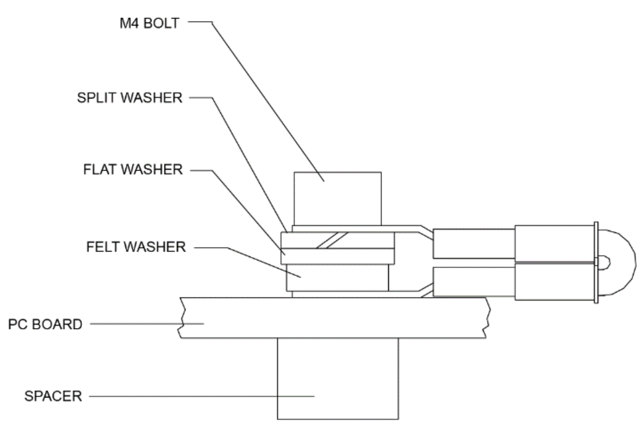


Figure 57. Ground Jumper

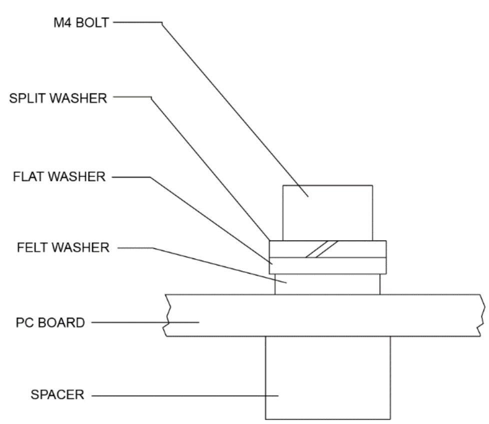


Figure 58. Mounting Hardware

3. Place the thumbnuts (just removed in step 3) on the four bolts of your original set of boards and then place the boards into the anti-static bag.
4. Connect the spare board stack to the Receiver board. Align the boards to the 26-pin header connected to the Receiver board. As you connect the board stack, connect the transmit cable to the Receiver PCB in the same orientation as was installed on the original board set.

5. Tighten the four M4 bolts to 1.20 N.m. (10.6 In-LB).
6. Check the CompactFlash Memory Card is fully seated into the connector located on the WHP PCB.
7. Check the communication switch is set to RS-232 or RS-422 as needed.
8. Check the ISM cable connector is fully seated into the connector on the WHP PCB.
9. Install the Transducer into the Pressure Case. Use new O-Rings and desiccant.

Installing the Beam Cosine Matrix

The beam cosine matrix table corrects small transducer beam misalignment angles that occur during manufacturing. Contact TRDI Field Service to have the file emailed to you. This file may be pre-installed if the ADCP serial number was known when the board stack was ordered.

To install the beam cosine matrix:

1. Connect the ADCP I/O cable and apply power.
2. Start *TRDI Toolz* and confirm that the Workhorse II ADCP is communicating normally.
3. Run the script file *xxxx BEAM COSINE MATRIX.txt* (where *xxxx* is your system serial number). The Beam Cosine Matrix table will automatically be updated. You can verify the beam cosine matrix loaded by viewing the PS3 results under the label Q14.

```
>ps3
↓
↓
Instrument Transformation Matrix (Down):    Q14:
  1.4691   -1.4705    0.0078   -0.0067       24069  -24092     127    -109
 -0.0068    0.0078   -1.4618    1.4606        -111     127  -23950   23930
  0.2663    0.2657    0.2657    0.2661        4363    4354    4353    4359
  1.0367    1.0350   -1.0359   -1.0374       16985   16957  -16972  -16996
Beam Angle Corrections Are Loaded.
>
```

Installing the Pressure Sensor Coefficients

If the ADCP included a pressure sensor, the pressure sensor coefficients must be loaded. Contact TRDI Field Service to have the file emailed to you. This file will be pre-installed if the ADCP serial number and/or original pressure coefficients were known when the board stack was ordered.

To install the Workhorse II pressure sensor coefficients:

1. Connect the ADCP I/O cable and apply power.
2. Start *TRDI Toolz* and confirm that the Workhorse II ADCP is communicating normally.
3. Run the script file *xxxxx WH2 PRESSURE SENSOR COEFFICIENTS.txt* (where *xxxx* is your system serial number) to install the pressure sensor coefficients appropriate to the system. The Pressure coefficients will automatically be updated. You can verify the pressure sensor coefficients loaded by viewing the PS0 results.

```
>ps0
↓
↓
Pressure Sens Coefficients:
              c3 = +2.1725004E-212
              c2 = +2.013757E-08
              c1 = +1.264614E-01
          Offset = +0.000000E+00
↓
↓
>
```

Remember to send the AZ command to zero the pressure sensor prior to putting the ADCP in water.

Testing the System After Board Replacement

To test the system after replacing the boards:

1. Connect the I/O cable and power and test the ADCP as shown in Chapter 5, Testing the Workhorse II. All PA tests should pass when run in water and the PC tests should pass with the ADCP out of water.
2. To test that the transmit cable is connected properly, run the PT4 test. The test failure example shown below is what you would see for a missing or improperly attached transmit cable.

```
[BREAK Wakeup A]
Workhorse II Broadband ADCP Version 77.xx
Teledyne RD Instruments (c) 1996-2021
All Rights Reserved.
>pt4

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

3. Perform a field calibration of your compass (see Compass Calibration).
4. Format the CompactFlash Memory Card (see Formatting the CompactFlash Memory Card). You have completed the Workhorse II Spare Board Installation.
5. If the ADCP included optional feature upgrades, verify the features are installed by sending the OL command. If the features were not pre-installed, contact TRDI Field Service to have the file emailed to you. See Installing Feature Upgrades for instructions.

Mariner I/O Cable Dry End Connector Assembly

The Mariner I/O cable connects the transducer assembly to the deck box. This cable is typically pulled through the vessel inside of conduits that may be unable to accommodate the dry end connector. To facilitate installation through conduits, the cable is provided without the dry end connector installed. Once the cable has been pulled through the vessel, the dry end connector is installed. The following procedure explains the steps required to install the dry end connector.

Tools and Equipment Requirements

- Workhorse II Mariner ADCP I/O cable pigtail kit (dry end in bag)
- 24-pin dry end cable connector (Part Number 85106RC2024P50) with pins

Tools and Equipment Requirements (User Supplied)

- Standard wire strippers for 18 - 22 AWG wire.
- Heat Gun
- 6 inches of 0.500 inch (12.7 mm) general purpose heat shrink tubing
- Wire cutters
- Multi-meter

The following items can be purchased from:

Daniels Manufacturing Corporation
526 Thorpe Road
Orlando, FL 32824
Phone: (407) 855-6161
Web Site: www.dmctools.com

- Crimping tool: AF8 M22520/1-01
- Turret Head TH1A: M22520/1-02

May be purchased as a pair AF8-TH1A Crimp Tool with TH1A Turret Head.

- Extraction Tool: MS24256R20 (DRK20)
- Insertion Tool: MS24256A20 (DAK20)

Installation Instructions

To install the dry end cable connector:

1. Strip the black polyurethane jacket back approximately 40 mm (1.5 inch).
2. Slide on a 76.2 mm (3 inch) length of heat shrink tubing. Using a heat gun, shrink the tubing around the end of the cable. Add a second layer of heat shrink tubing to strengthen the cable.
3. Remove the cable clamp and rubber grommet from the connector. Slide the grommet onto the cable.
4. Strip back the insulation on the wires approximately 6 mm (0.25 in.).
5. Insert the wire into the pin's crimp barrel and ensure that it has penetrated correctly by checking that it may be seen through the lateral hole in the barrel. Using the crimping tool, crimp a pin on each wire. Squeeze the crimp tool handles firmly until a click is heard. The crimp tool should spring open when released.

Do not solder the wires as this will cause the pin to be deformed and it will not fit into the connector.

6. Repeat step 5 for each of the wires.
7. Insert the pins in the connector using the insertion tool (MS24256A20 (DAK20)). The pin out configuration is shown in **Figure 23**, page 31.

Insert the pins from the center of the connector and work your way out. This makes it less likely to bend or break the wires off of the pins.

8. Slide the rubber grommet over the heat shrink tubing and onto the cable clamp. Insure the cable clamp and rubber grommet will grip the cable's black polyurethane jacket (covered with the two layers of heat shrink tubing), not the single wires.
9. Attach the loose half of the cable clamp over the rubber grommet using the two screws.

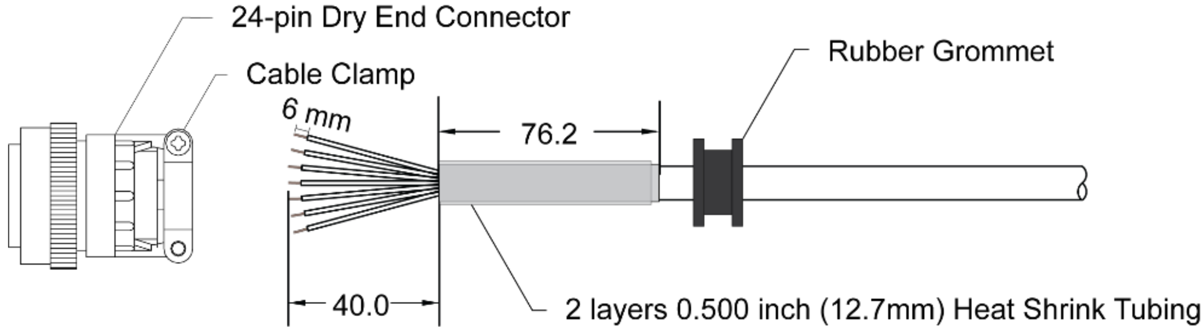


Figure 59. Mariner I/O Cable Construction

Checking the Wiring

After the connector is installed, use a multi-meter to confirm that the connector has been wired properly by performing an end-to-end continuity and adjacent pin isolation check (see **Figure 23**, page 31).

1. Confirm that all pins in the dry end connector are not shorted. Check for >2 Mohms of resistance between each of the dry end pins.
2. Using a 2-inch jumper wire (such as a paper clip) connect pins 1 and 2 of the wet end connector. Confirm that the associated dry end pins are shorted together. The resistance should nominally be 0.033 Ohms per meter of cable conductor at 20°C. For example, a 30 meter cable has a nominal conductor resistance of 1 Ohm at 20°C. The total resistance should be 0.033 x 30 x 2 conductors = 1.98 Ohms.
3. Move the jumper to pins 1 and 3 of the wet-end connector and confirm that pins 1 and 3 are wired properly.
4. Repeat step 3 for each of the remaining pins in the wet-end connector. Each time use pin 1 as the reference and then the other pin will be the pin that has not been tested.

Chapter 5

TESTING THE WORKHORSE II

In this chapter, you will learn:

- Testing the Workhorse II with *TRDI Toolz*
- Test Results
- Dock Side Tests
- Sea Acceptance Tests

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

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

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

For stationary deployments, the *TRDI Toolz* tests are the only tests required to verify the ADCP is operating correctly. When the ADCP is mounted to a moving vessel, use the Dock Side tests and the Sea Acceptance tests.

Testing the Workhorse II with *TRDI Toolz*

To test the ADCP:

1. Setup the communication parameters between *TRDI Toolz* and the ADCP.
2. Wake up the ADCP by pressing the button.
3. On the **Tools** menu, select **Script Editor**.
4. Click the **Open** icon and select the *TestWH.txt* file.

The script file *TestWH.txt* is included with *TRDI Toolz* version 1.4.0.3 or higher. A copy of it is shown in the TRDI Toolz help file and can be copy/pasted into the script editor window.

Time Set

The script file will send the ADCP the **TS?** command. This will show the current setting of the real time clock. For example;

```
>TS?
TS = 22/06/17,07:31:27 --- Time Set (yr/mon/day,hour:min:sec)
>
```

Display System Parameters

The script file will send the **PS0** command. This tells the ADCP to display specific information about your ADCP. For example, a system with an ISM compass will show:

```
>ps0
  Instrument S/N:  0
       Frequency:  614400 HZ
   Configuration:  4 BEAM, JANUS
     Match Layer:  10
      Beam Angle:  20 DEGREES
    Beam Pattern:  CONVEX
     Orientation:  UP
       Sensor(s):  ISM  DEPTH  TEMPERATURE  PRESSURE
Pressure Sens Coefficients:
```

```
              c3 = +0.000000E+00
              c2 = +0.000000E+00
              c1 = +8.240925E-02
          Offset = +0.000000E+00

Temp Sens Offset:  -0.13 degrees C

    CPU Firmware:  77.00z Prototype
   Boot Code Ver:  Required:  1.22   Actual:  1.22
    DEMOD #1 Ver:    2b, Type:   0
    DEMOD #2 Ver:    2b, Type:   0
    PWRTIMG  Ver:    2b, Type:   0

Board Serial Number Data:
   57  00 00 03 8F 26 DB  23 WHP727-2022-03A
   06  00 00 03 D4 C2 F9  23 PIO727-3023-13B
   07  00 00 08 D9 09 58  09 REC727-1000-03F

ISM Part Num: SNR71B-1048-61
ISM firmware version: 45.05
ISM serial number: 030000E3 23D7E86F
>
```

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

Instrument Transformation Matrix

The script file will send the **PS3** command. This shows information about the transducer beams. The Workhorse II uses this information in its coordinate-transformation calculations; for example, the output may look like this:

```
ps3
Beam Width:   3.7 degrees

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

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

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

If the Workhorse II has beam angle errors, they are reflected in the instrument transformation matrix and the Beam Directional matrix. This matrix, when multiplied by the raw beam data gives currents in the *x*, *y*, *z*, and *e* directions.

Pre-deployment Test

> The pre-deployment test requires you to immerse the transducer faces in water. If you do not, some of the tests may fail. Running the tests in air will not harm the ADCP.

The script file will send the **PA** diagnostic test. This checks the major Workhorse II modules and signal paths. For example, the output may look like this:

```
>PA
PRE-DEPLOYMENT TESTS
CPU TESTS:
  RTC.....................................PASS
  RAM.....................................PASS
  ROM.....................................PASS
RECORDER TESTS:
  PC Card #0..............................DETECTED
    Card Detect...........................PASS
    Communication.........................PASS
    DOS Structure.........................PASS
    Sector Test (short)...................PASS
DSP TESTS:
  Timing RAM..............................PASS
  Demod  RAM..............................PASS
  Demod  REG..............................PASS
  FIFOs...................................PASS
SYSTEM TESTS:
  XILINX Interrupts... IRQ3  IRQ3  IRQ3 ...PASS
  Wide Bandwidth..........................PASS
  Narrow Bandwidth........................PASS
  RSSI Filter.............................PASS
  Transmit................................PASS
SENSOR TESTS:
  H/W Operation...........................PASS
```

Testing the Sensors

The script file will send the **PC2** test to display heading, pitch angle, roll angle, up/down orientation, and temperature in a repeating loop at approximately 0.5-sec update rate.

To test the sensors, rotate and tilt the system and verify the Pitch and Roll sensor data is reasonable. Rotate the system clockwise and verify the heading increases. Validate the accuracy at 0, 90, and 180 degrees. If the heading is off by more than 2 degrees, calibrate the compass. If the pressure is not zero, zero the pressure sensor with the **AZ** command.

```
Press any key to quit sensor display ...
Heading   Pitch    Roll   Up/Down    Attitude Temp    Ambient Temp   Pressure
301.01°  -7.42°  -0.73°    Up          24.35°C         22.97°C        0.0 kPa
300.87°  -7.60°  -0.95°    Up          24.36°C         22.97°C        0.0 kPa
300.95°  -7.60°  -0.99°    Up          24.37°C         22.97°C        0.0 kPa
300.71°  -7.61°  -0.96°    Up          24.37°C         22.98°C        0.0 kPa
```

Sign of Angle for a Unit Facing	Up	Down
Pitch - Beam 3 higher than Beam 4	+	+
Roll - Beam 2 higher than Beam 1	+	-

Any key pressed exits this command and returns the user to the command prompt.

Beam Continuity

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

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

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

Collecting Statistical Data...
  52  48  50  43

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

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

If the **PC1** test fails, your system may still be okay. In this case deploy the ADCP into a bucket or container of water (preferably at least 0.5 meters deep). Record some data using *TRDI Toolz* and the log file (**F3** key), or record data straight to the recorder card if your ADCP has one. Then look at the data using the *WinADCP* program and make sure that the echo amplitude counts in the 1st depth cell for all beams is between 128 and 192. If they are not, contact Field Service for further troubleshooting tips.

Dock Side Tests

The following checks should occur at Dock Side prior to performing the Sea Acceptance Tests. These tests will verify the Workhorse II ADCP is ready for the Sea Acceptance Tests and confirm the peripherals attached to the ADCP.

These tests only apply to moving vessel deployments.

Dock Side Diagnostic Test

The following test will confirm the connection of the Workhorse II Deck box (Mariner) to the Transducer or Workhorse II to the computer.

Table 6: Dock Side Test Set Up

Set up	Description
Platform/Vessel	The vessel should be tied to the dock or at anchor. The transducer should be in water. All other sonar devices and equipment should be turned off.
Workhorse II	Connect the ADCP as described in Setting up the Workhorse II System. The Navigation connection may or may not be connected at this point.
Computer	The *TRDI Toolz* program should be running, communications port setting (F5) to match the connection to the PC and Workhorse II ADCP baud rate requirements (default 9600,N,8,1).

Use the following steps to interconnect the Workhorse II system and to place the ADCP in a known state.

1. Interconnect and apply power to the system as described in Setting up the Workhorse II System.
2. Start the *TRDI Toolz* program.
3. Press **End** to wake up the ADCP. Send the **PA** command to the ADCP. See Pre-deployment Test for an example of the test result printout.

Dock Side Peripheral Tests

The Workhorse II requires (at minimum) input for heading (true north) and for position fixes (GPS). Additionally, the Workhorse II can make use of pitch and roll data to correct for the tilt.

Pitch and Roll can be input and combined with Workhorse II data in the computer software *VmDas*. This heading input is done through the communications port of the computer with the TRDI proprietary NMEA string $PRDID.

Navigation data can only be combined with Workhorse II data in the computer software *VmDas*. This navigation input is done through the communications port of the computer with the NMEA proprietary strings $GGA and $VTG.

See the VmDas User's Guide and/or the WinRiver II User's Guide for help on integrating NMEA Devices.

Table 7: Dock Side Peripheral Tests Set up

Set up	Description
Platform/Vessel	The Navigation and Pitch/Roll sensors should be attached to the appropriate place on either the Workhorse II deck box or the computer communication port. The devices should be on and should stable.
Workhorse II	The Workhorse II should be connected as described in Setting up the Workhorse II System, AC Power connected to the deck box/ADCP, and the power switch turned on.
Computer	The *TRDI Toolz* program should be running, communications port setting (F5) to match the connection to the PC and Workhorse II ADCP baud rate requirements (default 9600,N,8,1).

Testing the Navigation Connections to the Computer (VmDas)

Start *VmDas* in the Data Collect mode. On the **View** menu, select **NMEA Communications**. Confirm that the Navigation Device NMEA string is viewable and the $GGA string is present.

The **Navigation Data** window in *VmDas* (see **Figure 60**) shows a text box of the position and velocity data from a NMEA navigation device. You can use this to verify the navigation connections.

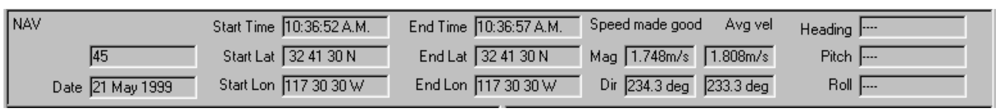


Figure 60. Testing the Navigation Connections

Testing $HDG Heading Connections to the Computer (VmDas)

Start *VmDas* in the Data Collect mode. On the **View** menu, select **Nmea Communications**. Confirm that the Navigation Device NMEA string is viewable and the $HDG string is present. Note that the data for this information may appear on the same communications port as the navigation data or on a separate input port.

Testing $PRDID Heading Connections to the Computer (VmDas)

Start *VmDas* in the Data Collect mode. On the **View** menu, select **Nmea Communications**. Confirm that the Navigation Device NMEA string is viewable and the $PRDID string is present. Note that the data for this information may appear on the same communications port as the navigation data or on a separate input port.

Testing the Navigation Connections to the Computer (WinRiver II)

Start *WinRiver II* in the Acquire mode. On the **View** menu, select **Device Logs**. Confirm that the Navigation Device NMEA string is viewable and the $GGA string is present.

Table 8: Dock Side Peripheral Test Results

Test	Test Criterion
External Heading NMEA Connection Test	Verify that the Navigation Device NMEA string is viewable and the $GGA string is present.
External Heading NMEA Connection Test	Verify that the Navigation Device NMEA string is viewable and the $HDT or $HDG string is present.
External Heading NMEA Connection Test	Confirm that the Navigation Device NMEA string is viewable and the $PRDID string is present.

Sea Acceptance Tests

This procedure is intended to test the Workhorse II at sea. This procedure assumes that the Dock Side Testing (see Dock Side Tests) procedure has been run and that all of the items have passed or been confirmed to be operational. The following tests will not obtain favorable results unless all of this work has been performed.

These tests only apply to blue water moving vessel deployments using *VmDas*. See the *VmDas* User's Guide for instructions on how to use this program.

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

At Sea Testing includes tests for Acoustic Interference, Profiling Range, and Profiling Reasonableness testing. For each of these tests, the following equipment and ADCP set up requirements are recommended.

Equipment Required

- Workhorse II 300 kHz, 600 kHz, or 1200 kHz ADCP with firmware 16.xx or greater
- Computer
- *VmDas* Program
- *WinADCP* Program
- Navigation Interface Connected
- Heading Interface Connected

VmDas Set up

1. Start *VmDas*. On the **File** menu, click **Collect Data**. On the **Options** menu, click **Load**. Select the *Default.ini* file and click **Open**.
2. On the **Options** menu, click **Edit Data Options**. Click the **ADCP Setup** tab. Set the **Ensemble Time** to the **Ping as fast as possible**.
3. Select the **Use Command File** box. Use **Table 9** to choose a command file for your ADCP and load it into *VmDas* using the **Browse** button.

Table 9: Command Files

File Name	Description
WH300DEF.txt	Default set up for a WH 300 kHz ADCP to provide the most range with the optimal precision.
WH600DEF.txt	Default set up for a WH 600 kHz ADCP to provide the most range with the optimal precision.
WH1200DEF.txt	Default set up for a WH 1200 kHz ADCP to provide the most range with the optimal precision.

4. On the **Options** menu, click **Edit Data Options**. Click the **Averaging** tab. Set the **Short-Term Average** to 300 seconds (5 minutes). Set the **Long-Term Average** to 600 seconds (10 minutes).

Interference Test

The Workhorse II transmits and receives acoustic signals from the water. If other sonar devices are operating on the platform at the same time as the ADCP it is possible for those signals to bias the ADCP data. Therefore, all ADCPs must be tested to ensure that they are not receiving interference from other sonar equipment on board the vessel. The following Interference Test will determine if there is interference from other devices on board the vessel.

Interference Test Platform Test Set up

This test requires that the platform be in water deeper than the ADCP's maximum expected profiling range. Use the following table to determine the minimum water depth required.

Table 10: Interference Test Minimum Water Depth Requirement

300 kHz ADCP	600 kHz ADCP	1200 kHz ADCP
400 meters	150 meters	60 meters

The platform speed for this test is drifting. The motors may be running if required for platform safety. The test sequence starts with ALL sonar and non-essential electronic equipment turned off. Only the ADCP should be on for the first test. This test establishes a base line for the interference and is critical to the rest of the tests. After a 10-minute period the first sonar device is turned on, transmission started, and the data is reviewed for interference terms. At the end of this 10-minute period the first sonar device is turned off and then the next sonar device is turned on and started pinging for 10 minutes. This process repeats for each of the sonar devices.

Interference Test Computer Screen Display Set up

View the RAW data (*.ENR files) being collected by the *VmDas* program in the *WinADCP* or *WinADCP* program contour plots for echo intensity data. This data will show the single ping return levels.

How to Identify Interference

If there is an interference term, the echo intensity data will show spurious echo intensity jobs. The interference term appears as the periodic green blocks in the data set. The interference is somewhat lost in the upper part of the profile however it can be seen clearly seen once the system reaches the noise floor (the point where signals are no longer being returned from the water).

Interference terms seen anywhere in the echo intensity profile data will result in a bias to the ADCP data.

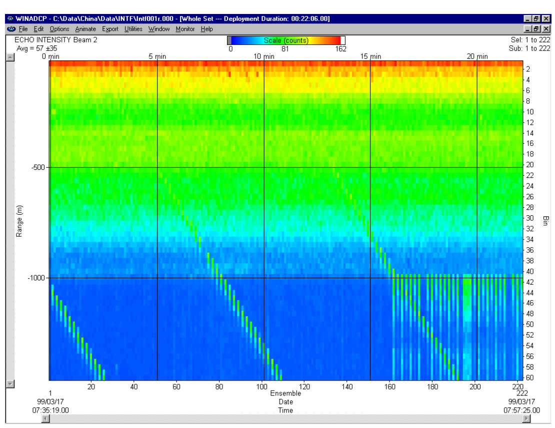


Figure 61. Interference Test

Water Profile Range Test

The range of any ADCP is directly dependent on the level of backscattering material in the water, the transmit power into the water, the received sensitivity, and the level of the background noise. Each of these effects the range of the system in different ways, but in the end can result in reduced or extended range as follows.

- The ADCPs transmit power and receive sensitivity are fixed based on the transducer frequency. However, these may be affected by installation of an acoustic window in front of the transducer. A window will absorb both sound transmitted by the ADCP, and the sound returned from backscatter in the water.
- The volume of the backscatter in the water will affect the range. All specifications for range assume that there is a certain amount of backscatter in the water. The backscatter volume is not controllable in any way.
- The background noise changes as the platform's speed increases or decreases. There are two types of noise created by the moving platform; first, there is the noise due to propeller and engines; and second, there is the noise created by the rushing water across the platform and ADCP transducer.

This test is used to determine the effects of the background noise on the range of the ADCP. This information can be used to determine the optimum speed of the platform to obtain the desired range required.

Water Profile Range Platform Test Set up

This test requires that the platform be in water deeper than the ADCP's maximum expected profiling range. Use the following table to determine the minimum water depth required.

Table 11: Water Profile Range Test Minimum Water Depth

300 kHz	600 kHz	1200 kHz
250 meters	100 meters	40 meters

The platform course for this test is a continuous straight line. The speed of the platform will be varied during this test. At each speed, the system will be set to collect data for a minimum of 10 minutes. The following table lists the recommended speeds.

Table 12: Water Profile Range Test Platform Speed

Test #	Speed
Speed 1	Drifting
Speed 2	3 knots
Speed 3	6 knots
Speed 4	9 knots
Speed 5	12 knots
Speed 6	Maximum Speed

Water Profile Range Computer Screen Display Set up

View the Tabular Display of the Long-Term Average data (10-minute averages) in the *VmDas* program.

How to Determine the Maximum Range of the ADCP

The data collected in the long-term average (10 minutes) tabular display will be used to determine the maximum range of the ADCP. The maximum profiling range of the system is determined by locating the last valid bin and then using that ping to determine the range. To determine the last valid bin the following criterion is used:

- The last bin must be above the bottom side lobe area
- The bin must be > 25% of the sum of 3-beams Solutions (percent good 1) and 4-beams Solutions (percent good 4), [(PG1 + PG4) > 25%].
- The correlation value for at least 3 beams must be above the threshold of 64 counts

Locate the last valid bin for each of the speeds and fill in the table below.

Platform Speed	Last Valid Bin Number	Range to Last Bin	Average RSSI Value at Last Bin

Notes:

- Platform Speed must be input as a measurement from the Bottom Track (if in range) or the GPS speed.
- Range to Last Bin is calculated as follows: ((bin size) * (last bin number)) + (NF command)
- Average RSSI Value at Last Bin is the average of the 4 beams RSSI values in the last bin number

The results from the above test should be compared to the specified nominal range of the system. Assuming that there are sufficient scatterers in the water, the acoustic window is not attenuating the signal, and that that the platform background noise is variable there should be a speed at which the nominal range of the system is obtained.

Ringing Test

The ADCP transmits an acoustic pulse into the water. The main lobe of this pulse bounces off particles in the water and the signals returned from these particles are used to calculate the velocity of the water. The main lobe of the transmitted pulse is what we are using to process and calculate a velocity. The transmitted pulse, however, is made up of many side lobes off the main lobe. These side lobes will come in contact with metal of the transducer beam itself and other items in the water.

The energy from the side lobes will excite the metal of the transducer and anything bolted to the transducer. This causes the transducer and anything attached to it to resonate at the system’s transmit frequency. We refer to this as “ringing.” If the ADCP is in its receive mode while the transducer is ringing then it will receive both the return signals from the water and the “ringing.” Both signals are then processed by the ADCP. The ringing causes bias to the velocity data.

All ADCPs “ring” for some amount of time. Therefore, each ADCP requires a blanking period (time of no data processing) to keep from processing the ringing energy. Each ADCP frequency has a different typical ringing duration. A blanking period (time of not processing data) is required at the beginning of each profile. The blanking distances recommended for the typical ringing period for each Workhorse II frequency is shown in the following table.

Table 13: Recommended Blanking Distance

Frequency (kHz)	200m Rated	6000m Rated
1200	0.05 to 0.51m	0.05 to 1.05m
600	0.1 to 1.02m	0.1 to 2.1m
300	0.2 to 2.04m	0.2 to 3.54m

Ringing will bias the velocity estimation to a lower value than it should be. However, when the platform motion is removed from the water profile data it will appear as a large velocity, which is the opposite of what it is really doing. This effect is caused because the vessel motion portion of the water profile data has been biased low.

Ringing Test Platform Test Set up

The key to success on this test is that the water velocity and direction does not change over the entire test period of 120 minutes. This may be difficult to adhere to in regions with large tidal effects. The test requires that the platform be within the ADCP bottom tracking range so that valid bottom track can be used. Use the following table to determine the optimum water depth range required.

Table 14: Ringing Test Water Depth Requirement

300kHz ADCP	600kHz ADCP	1200kHz ADCP
100-200 meters	50-100 meters	10-20 meters

Platform speed should be held to as fast a speed as possible without losing any bottom tracking data for a period of 30 minutes. Typically, this will be a speed of 6-9 knots. Some experimentation may be required to find the maximum bottom track speed for the given depths above.

Ringing Test Computer Screen Display Set up

The Magnitude and Direction Profile Display of the Long Term Average data (10 minute averages) will be viewed in the *VmDas* program.

How to Determine the Ringing Test Results

Viewing the Long-Term average of the magnitude and direction profile data, look for unreasonable shears from bin 1 to bin 2 to bin 3 and so on. If an unreasonable shear is seen, this is most likely ringing and your blanking needs to be increased by the following formula:

(bin size) * (last bin number with ringing) * 0.80

*The total blanking period is typical blanking period plus the increased blanking period required. The above value should be used to change both the NF and WF commands in all configuration files for this ADCP.

Transducer Alignment Test

This test only applies to Workhorse II Mariner systems using an external heading.

The mounting alignment of the transducer to the relative position of the heading input from the vessel is critical in the velocity estimates made by the ADCP. If either of these are not known and corrected for, it will result in both directional and velocity estimate errors in the velocity data.

It is possible to confirm if the transducer alignment is correct by collecting data over the same water in several different directions. If the transducer is aligned, then the both the magnitude and direction of the currents will appear the same in all directions that the platform travels.

Platform Testing Setup

The key to success on this test is that minimal water velocity and direction change over the entire test period. The following test will take a minimum of five hours to collect. This length of time is required in order to obtain enough data samples to reduce the noise sufficiently. This test requires that the platform be within the ADCP bottom tracking range, so that valid bottom track can be used, and that reliable GPS data be available (DGPS is recommended). Use the following table to determine the optimum water depth range required.

Table 15: Transducer Alignment Test Water Depth Requirement

Mariner 300 kHz	Mariner 600 kHz
80-160 meters	25-75 meters

The platform speed is to be held at a constant speed. Any speed between 5 to 10 knots is acceptable, however once a speed is selected then the vessel should maintain that speed during the entire course. The course for this test contains a minimum of five legs. Each leg must be a minimum of 30 minutes long (1 to 2 hours per leg is the optimal time). The course of ship travel is shown in **Figure 62**. All data must be collected in beam coordinates.

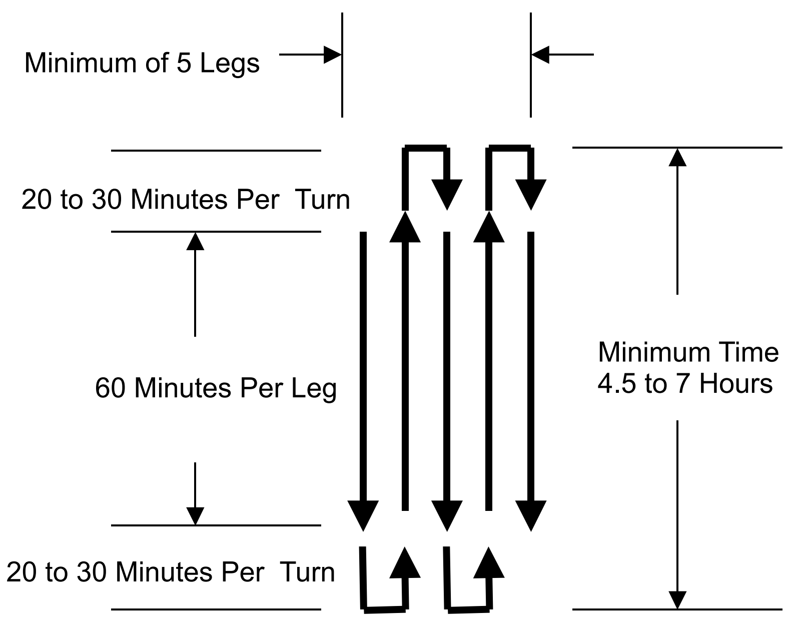


Figure 62. Transducer Alignment Test

Computer Screen Display Setup

View the *VmDas* ship track display of bin 3 with the bottom track reference. The Long-Term Average (5-minute averages) data should be viewed.

Each of the vertical lines represents the point when the vessel changed directions.

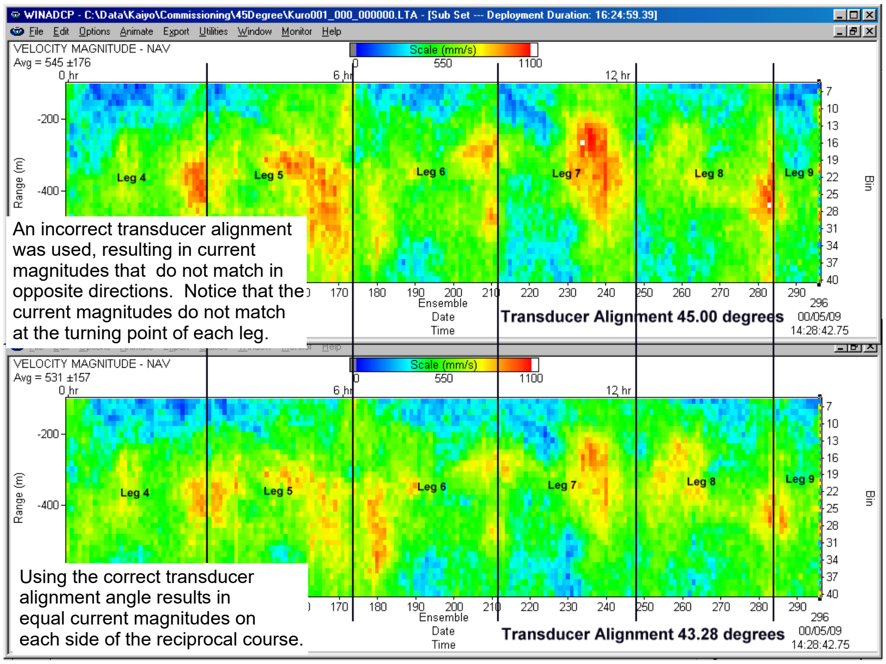


Figure 63. Transducer Alignment Display

Transducer Alignment Results Sheet

A pass condition is if the velocities in each of the ship track plotted directions has the reasonably the same magnitude and direction. It is common to see some wild velocity magnitude and directions. This happens because of the effects of the latency of the heading updates for a GPS heading input.

If the direction of the currents is not the same in each of the directions, then it will be necessary to enter in a transducer misalignment angle. The 5-minute averages of both GPS and Bottom Track Direction are compared in at least 2 of the legs traveled. An average direction along each leg is calculated for both the GPS and Bottom Track data. The difference in the average directions is the misalignment angle.

Record the results of this portion of the Transducer Alignment with Bottom Track Reference with the formula:

Misalignment Angle = (GPS Average Direction) – (Bottom Track Average Direction)

Misalignment Angle Required	Degrees

Changing the transducer alignment angle, reprocessing the data, and finally playing back the same data file again allows you to confirm if the misalignment angle correction is correct. A pass condition is if the velocities in each of the ship track plotted directions has the reasonably the same magnitude and direction. It is common to see some wild velocity magnitude and directions.

Record the results of the verification of the Transducer Alignment with Bottom Track Reference:

Alignment Verification	Pass/Fail

Change the data display reference from bottom track to the navigation data in the VMDAS program. A pass condition exists if little to no change in the velocity magnitude and direction occurred when switching to the navigation data reference

Record the results of this portion of the Transducer Alignment with Navigation Reference:

Navigation Verification	Pass/Fail

Water Profile Reasonableness Test

The mounting alignment of the Workhorse II transducer to the relative position of the heading input from the vessel is critical in the velocity estimates made by the ADCP. If either of these are not known and corrected for, it will result in both directional and velocity estimate errors in the water velocity data.

It is possible to confirm if the transducer alignment is correct by collecting data over the same water in several different directions. If the transducer is properly aligned, then both the magnitude and direction of the currents will appear the same in all directions that the platform travels.

Water Profile Reasonableness Platform Test Set up

The key to success on this test is that the water velocity and direction does not change over the entire test period of 120 minutes. This may be difficult to adhere to in regions with large tidal effects. The test requires that the platform be within the ADCP bottom tracking range so that valid bottom track can be used. Use the following table to determine the optimum water depth range required.

Table 16: Water Profile Reasonableness Water Depth Requirement

300 kHz	600 kHz	1200 kHz
100-200 meters	50-90 meters	10-40 meters

Platform speed is held at a constant 5 knots during the entire course. The course for this test contains 4 legs. Each leg must be approximately 4500 meters (except for leg 2 which will be one half the length of each of the other legs). The course will appear as shown in **Figure 64**. The actual starting direction is not critical if the course completes the pattern shown in **Figure 64**.

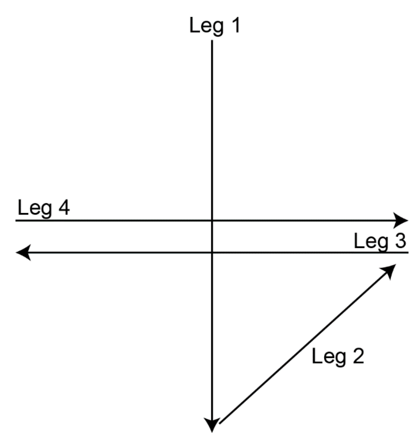


Figure 64. Water Profile Reasonableness Course

Water Profile Reasonableness Display Set up

View the *VmDas* Ship Track display of bin 3 with the bottom track reference. The Short Term Average (5 minute averages) data should be viewed.

How to Determine Water Profile Reasonableness

A pass condition is if the velocities in each of the ship track plotted directions has reasonably the same magnitude and direction. It is common to see some wild velocity magnitude and directions during turns. This happens as a result of the effects of the latency of the heading updates for a GPS heading input.

If the direction of the currents is not the same in each of the four directions, then it will be necessary to enter in a transducer misalignment angle. Changing the transducer alignment angle and playing back the same data file again allows you to determine the misalignment angle. The best way to perform this check out is to use incremental change of 5-10 degrees at a time.

Assuming that the misalignment angle was not required or could be determined, it is now possible to use the same data just collected to determine how reasonable the navigation data input is. Change the data display reference from bottom track to the navigation data in the *VmDas* program. There should be little to no change in the velocity magnitude and direction if the navigation data is a valid input for a reference.

Bottom Tracking Test

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

Before testing the Bottom Track capabilities, the Water Profiling Range Test must be performed. Through the results of this test, determine the platform speed in which the range to the last valid bin obtained the specified nominal range of the ADCP frequency being used.

If it was not possible to reach the specified nominal range during the Water Profiling Range test, then determine the speed at which it allowed the best range possible. Calculate the percentage of the nominal range that was obtained by the system.

Bottom Tracking Platform Test Set up

The key to this test is to operate the system in an area where both the minimum and maximum bottom tracking range can be obtained. The platform will travel over water that is very shallow (<10 meters) to very deep (greater than the maximum bottom track range). It does not matter if the water starts deep and goes shallow or vice-versa.

The course of the platform should be a relatively straight line. The platform speed should be no greater than the velocity recorded in the Water Profiling Range Test.

Bottom Tracking Computer Screen Display Set up

View the raw data display of the *VmDas* bottom track display window.

How to Determine Bottom Tracking Reasonableness

Viewing the bottom track velocity data, record the maximum and minimum average of the bottom track depths in the table below.

Beam Number	Minimum Depth (meters)	Maximum Depth (meters)
Beam 1		
Beam 2		
Beam 3		
Beam 4		

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

If the system was not able to water profile to the nominal range, then the bottom track range should be reduced to no more than the same percentage as the water profile loss.

If the Bottom Track did obtain the complete range and the Water Profile did not, then it is likely that there is insufficient backscatter in the water to obtain the specified range.

Chapter 6

TROUBLESHOOTING

In this chapter, you will learn:

- Basic Steps in Troubleshooting
- Troubleshooting a Communication Failure
- Troubleshooting a Built-In Test Failure
- Troubleshooting a Beam Failure
- Troubleshooting a Sensor Failure
- System Overview

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

Table 17: List of Least Replaceable Assemblies

LRA	Description
ADCP	The entire ADCP; includes the electronics, housing, transducer ceramic assemblies, and end-cap.
Deck Box (Mariner only)	The Deck Box contains all electronics necessary to supply power and provide user communication.
I/O Cable	Connects the ADCP with the Deck Box (Mariner) or Computer.
Serial Cable	Connects the Mariner Deck Box to the computer.
End-Cap	Includes the end-cap, connector, and internal I/O cable.
ADCP electronics	The spare boards kit Includes the PIO and WHP boards.
PC Card	Replaceable compact flash card.

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

Equipment Required

Special test equipment is not needed for trouble shooting and fault isolation. The required equipment is listed in **Table 18**. Any equipment satisfying the critical specification listed may be used.

Table 18: Required Test Equipment

Required Test Equipment	Critical Specification
DMM	Resolution: 3 ½ digit DC-Voltage Range: 200 mV, 2V, 20 V, 200V DC-Voltage Accuracy: ± 1% AC-Voltage Range: 200 V, 450 V AC-Voltage Accuracy: ± 2% Resistance Range: 200, 2 k, 20 k, 200 k, 20 MOhm Res.-Accuracy: ± 2% @ 200 Ohm to 200 kOhm Res.-Accuracy: ± 5% @ 20 MOhm Capacitance Range: 20 nF, 2 uF, 20 uF Capacitance Accuracy: ± 5%

Required Test Equipment	Critical Specification
Serial Data EIA Break-Out Box such as from International Data Sciences, Inc. 475 Jefferson Boulevard Warwick, RI 02886-1317 USA.	Model 60 or similar is recommended as it eases the troubleshooting of RS-232 communication problems significantly. Other manufacturers or models may be substituted.

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

Basic Steps in Troubleshooting

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

- Communication failure
- Built-In test failure
- Beam failure
- Sensor failure

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

Built-In test failures will appear when the system diagnostics are run. Use *TRDI Toolz* to identify the failing test.

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

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

Troubleshooting the Workhorse II

Although the Workhorse II is designed for maximum reliability, it is possible for a fault to occur. This section explains how to troubleshoot and fault isolate problems to the Least Replaceable Assembly level (see **Table 17**). Before troubleshooting, review the procedures, figures, and tables in this guide. Also, read the System Overview to understand how the Workhorse II processes data.

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

Troubleshooting Safety

Follow all safety rules while troubleshooting:

⚠	Servicing instructions are for use by service-trained personnel. To avoid dangerous electric shock, do not perform any service unless qualified to do so.
⚠	Complete the ground path. The power cord and the outlet used must have functional grounds. Before power is supplied to the Workhorse II, the protective earth terminal of the instrument must be connected to the protective conductor of the power cord. The power plug must only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.
⚠	Any interruption of the earthing (grounding) conductor, inside or outside the instrument, or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury.
⚠	Only fuses with the required rated current, voltage, and specified type must be used. Do not repair fuses or short circuit fuse-holders. To do so could cause a shock or fire hazard.
⚠	Do not install substitute parts or perform any unauthorized modifications to the instrument.
⚠	Measurements described in the manual are performed with power supplied to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury.
⚠	Do not attempt to open or service the power supply.
⚠	Any maintenance and repair of the opened instrument under voltage should be avoided as much as possible, and when inevitable, should be carried out only by a skilled person who is aware of the hazard involved.
⚠	Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

Troubleshooting a Communication Failure

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

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

If you have just received your Workhorse II from TRDI, the standard configuration is RS-232 for Sentinels and RS-422 for Monitors and Mariners.

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

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

Incorrect Wakeup Message

When you send a break and the wakeup message is not readable (garbled), this may indicate a communications mismatch or lost boot code.

- Sending a break causes "garbage" to appear on the screen. The "garbage" text may keep scrolling. This happens when the computer is using RS-232 and the ADCP is set for RS-422 or vice-versa. Check the RS-232/RS-422 switch on the PIO board (see Communications Setting).
- Sending a break causes "garbage" to appear on the screen. You can hear the ADCP "beep" when the break is sent. The "garbage" text does not keep scrolling. Check that the ADCP and computer are both using the same baud rate.

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

```
>{¡┐φ²∩╜╜²²jñ~ªñδgJ Checking 9600 baud rate
Checking 115200 baud rate
==
Workhorse II Broadband ADCP Version 77.xx
Teledyne RD Instruments (c) 1996-2021
All Rights Reserved.

>
```

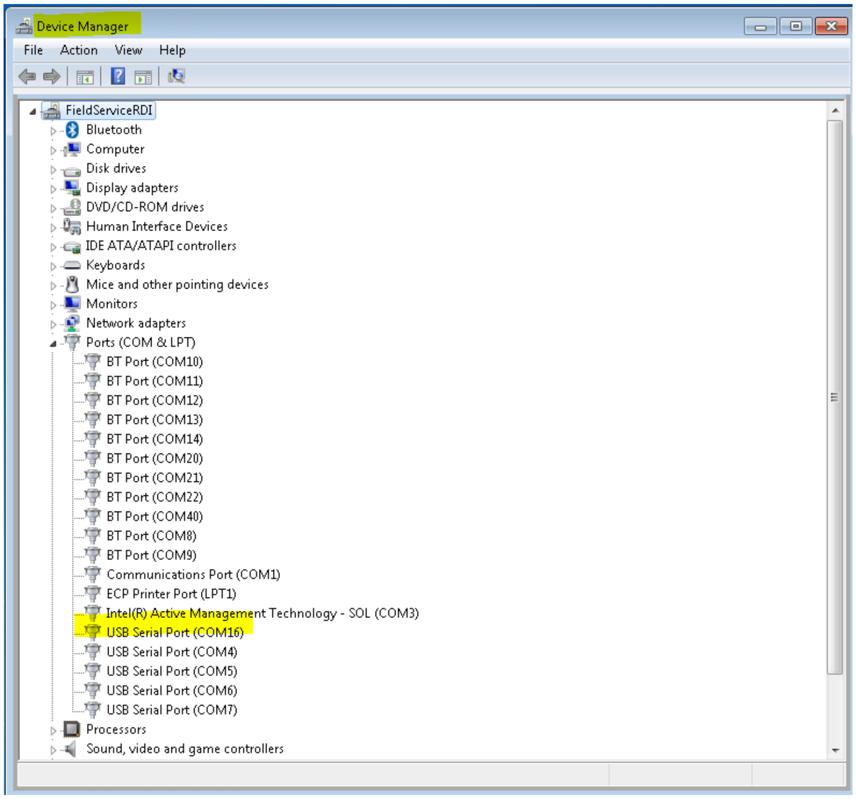
- If the ADCP gives a steady "beep" when power is applied, the ">" prompt appears on the screen, and an "X" appears when additional breaks are sent, this may indicate that the boot code has been lost. This can happen if you abort while downloading new firmware. Try downloading the firmware again.
- If you have problems communicating with the system, 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. The included USB adapter is P/N ES-U-1001-R10 USB to RS232 adapter with FT232R chipset from Connective Peripherals - US Store. Possibly any device with FTDI drivers and devices will also work.

Installing the USB to Serial Adapter Driver

If there is an available internet connection, Windows 10/11 will silently connect to the Windows Update service and install the USB driver on first connection. If needed, install the USB to Serial adapter Virtual COM Port (VCP) driver available on: https://ftdichip.com/drivers/

- If you don't know what com ports were added when using a USB to serial adapter, use *Windows Device Manager®* to determine the Com port as shown in the snapshot for a Windows 7® laptop.



If you have many ports as shown above and are not sure of which port is the USB to serial adapter one, remove the adapter, wait a moment, note the list of ports, reinsert the adapter and note the new port. In the example above, Com 16.

- If the system is set for RS-422, then check to make sure the host computer supports RS-422 or use an RS-422/RS-232 converter. TRDI recommends the B&B Electronics (http://www.bb-elec.com/) RS-422/RS-232 converter.

No Wakeup Message

When you send a Break and do not see the wakeup message, you need to isolate the problem to a computer fault, power, cable failure, or an ADCP problem.

Check the following items:

1. Connect the ADCP to a computer as shown in Setting up the Workhorse II System. Check that all cable connections are tight.
2. Is the ADCP AC power adapter working? Is the input voltage to the AC power adapter between 100 to 240 VAC? Is the output level 48 VDC?
3. If the ADCP is running from a battery, check that the battery voltage is above 30 VDC. ADCPs will work at 20 VDC with at least 400 milli amps; however, both lithium and alkaline battery packs with voltages below 30 VDC are at or near their end of life, and are approaching uselessness.
4. Is the computer hooked up properly? Does it have power?
5. Make sure that your computer and the *TRDI Toolz* programs are set up to use the communication port the serial cable is connected to on the computer.
6. In the case where the ADCP is only able to accept a SOFT BREAK due to telemetry components that will not "pass" a HARD BREAK to the ADCP and where you can cycle power, TRDI recommends that you consider removing power for one week. Re-apply power after a week and the ADCP should wake up.

> The ADCP automatically stores the last set of commands used in RAM. Removing power for one week allows the RAM to lose its backup power. When power is re-applied, the ADCP will then do a 'cold start' (see ADCP Checks).
>
> This is something that can be done without recovering the instrument. It assumes power can be cycled without recovering the ADCP and the ADCP is still functioning. The cost benefits of waiting a week needs to be weighed against the cost of divers recovering the ADCP.

Check the Power

The following test can be done with a voltmeter to check the power. Check the power going into the ADCP by measuring the voltage on the end of the cable that connects to the Workhorse II (see Workhorse II Cables). The voltage should be +48 VDC (using the standard AC adapter) or +48 VDC if you are using the Deck Box. If not, check the voltage at the other end of the cable, the AC adapter, and Deck Box (Mariner only).

Check the I/O Cable

This test will check the communication between the computer and Monitor or Sentinel Workhorse II.

To check the cable:

1. Disconnect both ends of the cable and measure the continuity using a DMM (see Workhorse II Cables for the wiring diagram). Correct any problems found.
2. Reconnect the I/O cable to host computer.
3. Load *TRDI Toolz* on your computer. Select the proper communications port (see the RDI Tools User's Guide for help on using *TRDI Toolz*).
4. For RS-232 communications, short pins 1 and 2 together on the female 7-pin connector that was plugged into the Workhorse II (see Workhorse II Cables). If you are using RS-422, connect a jumper

between pin 2 to pin 6 and another jumper between pins 1 to pin 5 of the underwater connector at the Workhorse II end of the cable.

5. Type any characters on the keyboard. The keys you type should be echoed on the screen. If you see characters, but not correctly (garbage), the cable may be too long for the baud rate. Try a lower baud rate. If this works disconnect the jumper on pins 1 and 2 and then push any keys on the keyboard. You should NOT see anything you type.
6. If the keys are echoed correctly on the screen, the computer and the communication cable are good. Re-connect the I/O cable to the Workhorse II. The above loop-back test does not show if transmit and receive pairs are interchanged. Thus, it is important that you check the wiring diagrams provided in Workhorse II Cables.

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

Check the Mariner Cables

This test will check the serial communication cable between the computer and Deck Box (Mariner only).

To check the cable:

1. Disconnect both ends of the cable and measure the continuity using a DMM (see Workhorse II Cables for the wiring diagram). Correct any problems found.
2. Reconnect the serial cable to host computer. Start the Teledyne RD Instruments software utility program *TRDI Toolz* on your computer. Make sure to select the proper communications port.
3. For testing a RS-232 cable, jumper pins 2 and 3 at the far end of the cable. To check a RS-422 cable, connect one jumper between pin 2 to 4, and one jumper between pins 7 to 8.
4. Type any characters on the keyboard. The keys you type should be echoed on the screen. If you see some characters, but not correctly, the cable may be too long for the baud rate. Try a lower baud rate. If this works disconnect the jumper and then push any keys on the keyboard. You should NOT see anything you type.
5. If you use cables that are **not** supplied by Teledyne RD Instruments you must make sure that transmit and receive pairs are not interchanged. The above loop-back test does not show if transmit and receive pairs are interchanged. Thus, it is important that you check the wiring diagrams provided in Workhorse II Cables.

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

6. If the keys are echoed correctly on the screen, the computer and the communication cable are most likely good. Re-connect the serial cable to the Deck Box. If the Workhorse II still does not wakeup, there could still be a problem with the Deck Box or ADCP.

ADCP Checks

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

To Cold Start the ADCP:

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

2. Remove *all* power to the ADCP.

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

3. Short TP10 to TP11 on the PIO board for 10 seconds.
4. Remove the jumper.
5. Connect the computer and connect power to the ADCP. Send a break to the ADCP. This should start the ADCP in the "cold start" mode.

To check the fuse:

Check the fuse on the PIO board is not blown (see Fuse Replacement for fuse replacement procedures).

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

Check for Boot Code Error:

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

Mariner Deck Box Checks

Once you have eliminated possible problems with the Workhorse II power, the serial data communication cable, and the host computer, that may leave the Deck Box as the source of the problem.

> The Deck Box contains Electrostatic Sensitive Devices. You must take accepted ESD prevention measures before opening the Deck Box.

To check the deck box:

1. One of the interconnecting cables inside the Deck Box may not be fully seated. Turn off power. Remove the top cover of the Deck Box and check that all of the cables are properly seated.
2. Check the Deck Box fuses are not blown (see Fuse Replacement for fuse replacement procedures).
3. Verify that the **Power Status** LED indicator located at the front panel next to the circuit breaker switch is lit. Make sure power to the Deck Box is connected and that the circuit breaker is in the ON position.
4. Verify that if you push the Reset button, the **Channel 1 In** LED on the front panel lights up temporarily. If it does, that means that the serial data receive channel seems to be functioning. If it does not light up, then the receive channel is not functioning.
5. If the **Channel 1 In** LED indicator on the front panel does light up while pushing **Reset**, verify that the **Channel 1 Out** LED next to it responses by lighting up temporarily as well. If the **Channel 1 Out** LED does light up, but there is no Wake-Up message displayed on the computer screen, then this indicates there is still a problem with the serial data transmit path. A serial data Break-Out box between the Deck Box and the serial communications cable would be helpful for narrowing down the problem.
6. If the Break-Out box does not indicate any data transmission from the Deck Box to the computer but the **Channel 1 Out** LED front panel indicator does, the problem most likely is with the Deck Box. Switch power to the Deck Box off, and after a few seconds on again. Repeat the Deck Box Checks from the beginning. If the system does not respond normally, it may be malfunctioning and you should contact Teledyne RD Instruments.

7. If the Break-Out box does indicate data transmission but there are no characters displayed on the computer screen, then the problem still lies with the communications cable or the computer.

Troubleshooting a Built-In Test Failure

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

- Spare Boards including PIO board, CPU board, and DSP board. These boards are held together with the standard M4 screw assembly and kept inside a protective anti-static bag.
- A disk containing your original beam cosine matrix table
- Tools for installation

The Spare Boards kit is not included with the system. You can order the kit by contacting Teledyne RD Instruments Customer Service department (see How to Contact Teledyne RD Instruments and **Table 5**, page 60).

When to use the Spare Boards Kit

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

- Cannot communicate to the Workhorse II and you have ensured that the serial port on the computer, Workhorse II Cable, Deck Box (Mariner only), and Workhorse II RS-232 to RS-422 converter (if applicable) are all working properly.
- Your Workhorse II fails any of the following PA tests at any time:

  CPU Tests:
  - RTC
  - RAM
  - ROM

  DSP Tests:
  - Timing RAM
  - Demod RAM
  - Demod REG
  - FIFOs

  System Tests:
  - XILINK Interrupts
  - Receive Loop Back Test

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

  Recorder Tests:

  Any recorder test fails {provided that the CF card has been checked for proper installation, operation and it is formatted; Use the *RE ErAsE* command to format the card. Do not remove and format the card using a card reader and Windows.}

  System Tests:

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

Sensor Tests:

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

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

- A damaged beam or its urethane surface
- Damage to the transducer beam connections below the copper shield
- If it passes all PA tests and yet the data is all marked as bad
- Fails the following PA test:

System Tests:

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

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

RSSI Filter

Transmit

Table 19: Pre-deployment Test (PA) Possible Cause of Failures

PA Test Name	Possible Cause of Failure

`Pre-Deployment Tests CPU Tests:`
`RTC`
`RAM`
`ROM`
	WHP board failed

`Recorder Tests:`
`PC Card #0`
`Card Detect`
`Communication`
`DOS Structure`
`Sector Test (short)`
`PC Card #1`
`Card Detect`
`Communication`
`DOS Structure`
`Sector Test (short)`
	CF card not plugged in
	CF card failed
	WHP board failed

`DSP Tests:`
`Timing RAM`
`Demod RAM`
`Demod REG`
`FIFOs`
	WHP board failed

`System Tests:` `XILINX Interrupts`	WHP board failed
`Receive Loop-Back`	WHP board failed

`Wide Bandwidth`
`Narrow Bandwidth`
`RSSI Filter`
	Not in water
	External interference
	WHP or Receiver board failed

`Transmit`	Not in water or PIO board failed
`Sensor Tests:` `H/W Operation`	PIO board failed Receiver board failed Pressure sensor failed ADCP laying on its' side

Troubleshooting a Beam Failure

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

If the PC1 test fails, your system may still be okay. In this case deploy the ADCP into a bucket or container of water (preferably at least 0.5 meters deep). Record some data using *TRDI Toolz* and the log file (**F3** key), or record data straight to the recorder card if your ADCP has one. Then look at the data using the *WinADCP* program and make sure that the echo amplitude counts in the 1st depth cell for all beams is between 128 and 192. If they are not, contact Field Service for further troubleshooting tips.

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

```
>PC1

BEAM CONTINUITY TEST

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

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

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

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

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

Troubleshooting a Sensor Failure

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

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

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

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

If the temperature sensor is bad, the data can still be collected with no effects to accuracy or quality. Contact TRDI about scheduling a repair of the temperature sensor at your convenience.

For external sensor verification, see Dock Side Tests.

Fault Log

To determine why a sensor failed, view the fault log. To view the fault log, start *TRDI Toolz*. Press the **End** key to wake up the ADCP. Type the following commands: **CR1**, **PA**, **FD**, **FC**. The fault log will be displayed by the FD command and is cleared by the FC command.

```
[BREAK Wakeup A]

Workhorse II Broadband ADCP Version x.xx
Teledyne RD Instruments (c) 1996-2021
All rights reserved.
[BREAK Wakeup A]
>CR1
>PA
|          (PA test results (not shown))
|
>FD
Total Unique Faults   =     2
Overflow Count        =     0
Time of first fault:    97/11/05,11:01:57.70
Time of last fault:     97/11/05,11:01:57.70

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

System Overview

This section presents a functional description of Workhorse II operation.

Operating Modes

The Workhorse II has two modes of operation: *command mode*, and *ping mode* (also referred to as "Deployment Saver" Mode). Depending on what mode the ADCP is in; it will go either to sleep or resume pinging.

Command Mode

Whenever you wake up your Workhorse II, power dissipation increases from less than 1 mW to around 2.2 W. If you leave the Workhorse II in command mode without sending a command for more than 5 minutes, the Workhorse II automatically goes to sleep. This protects you from inadvertently depleting batteries.

- If the ADCP receives a BREAK, it will go to the command prompt and wait for a command. The ADCP will wait at the command prompt for five minutes. If no commands have been sent, it will go to sleep (also called "Battery Saver" mode).
- If the ADCP receives a CS-command, it will go into the ping mode and begin pinging. If a TF-command (Time of First Ping) was sent prior to the CS-command, then the ADCP will go to sleep until the TF time occurs.
- If the ADCP does a COLD wakeup (i.e. an unknown state), it will go to the command prompt.
- If the ADCP is asleep for approximately nine hours, it wakes up to charge the capacitor used to maintain RAM. Once the capacitor is charged (this only takes a few seconds), the ADCP goes back to sleep.

Ping Mode

After you send commands to the Workhorse II that tells it to start collecting data, the Workhorse II goes into deployment saver mode. If power is somehow removed and later restored, the Workhorse II simply picks up where it left off and continues to collect data using the same set up.

- If the ADCP receives a BREAK, it will go to the command prompt, but stays in the ping mode. If a valid command is received, the ADCP will switch to the command mode. If no valid command is received, a warning will be displayed after four minutes, indicating that the system will self-deploy. After a total of five minutes with no input, the ADCP will resume pinging.
- If the ADCP does a COLD wakeup, the system will start a new deployment and starts pinging immediately unless a TF-command had been set after the last BREAK. In this case, the ADCP will go to sleep until the TF time occurs if the TF time is valid (i.e., not in the past).
- If the ADCP is asleep for approximately nine hours, it wakes up to charge the capacitor used to maintain RAM. Once the capacitor is charged, if a valid alarm is set for the next ping time, the ADCP goes back to sleep and waits for the alarm. If no alarm is set, the ADCP will resume pinging immediately, or wait for the TF time (if valid), and then start pinging.

Chapter 7

RETURNING SYSTEMS TO TRDI FOR SERVICE

In this chapter, you will learn:

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

Shipping the ADCP

This section explains how to ship the Workhorse II ADCP.

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

When shipping the Workhorse II ADCP 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 Workhorse II ADCP.

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

For repackaging with commercially available materials:

1. Use a strong shipping container made from wood or plastic.
2. Install a layer of shock-absorbing static-shielding material, 70-mm to 100-mm thick, around all sides of the instrument to firmly cushion and prevent movement inside the container.
3. Seal the shipping container securely.
4. Mark the container FRAGILE to ensure careful handing.
5. In any correspondence, refer to the Workhorse II ADCP 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 Workhorse II ADCP arrives with the minimum possible delay. Any deviation from these instructions increases the potential for delay.

Step 1 - Request a Return Material Authorization

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

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

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

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

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

Step 2 – Provide a MSDS as necessary

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

Step 3 - Ship via air freight, prepaid

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

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

Mark the Package(s)

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

Airport of Destination = San Diego
UPS Supply Chain Solutions Brokerage
15 E Oregon avenue
Philadelphia PA 19148
USA
Email: phldocreceipt@ups.com
Tel: + 1 (215) 952-1745

Step 4 - Urgent shipments

Send the following information by telephone to TRDI.

Attention: Customer Service Administration

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 Workhorse II ADCP arrives with the minimum possible delay. Any deviation from these instructions increases the potential for delay.

Step 1 - Request a Return Material Authorization

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

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

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

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

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

Step 2 – Provide a MSDS as necessary

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

Step 3 - Ship Via Air Freight, Prepaid

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

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

Mark the package(s) as follows:

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

Step 4 - Include Proper Customs Documentation

The Customs statement must be completed. It should be accurate and truthfully contain the following information.

- Contents of the shipment
- Value
- Purpose of shipment (example: “American made goods returned for repair”)
- Any discrepancy or inaccuracy in the Customs statement could cause the shipment to be delayed in Customs.

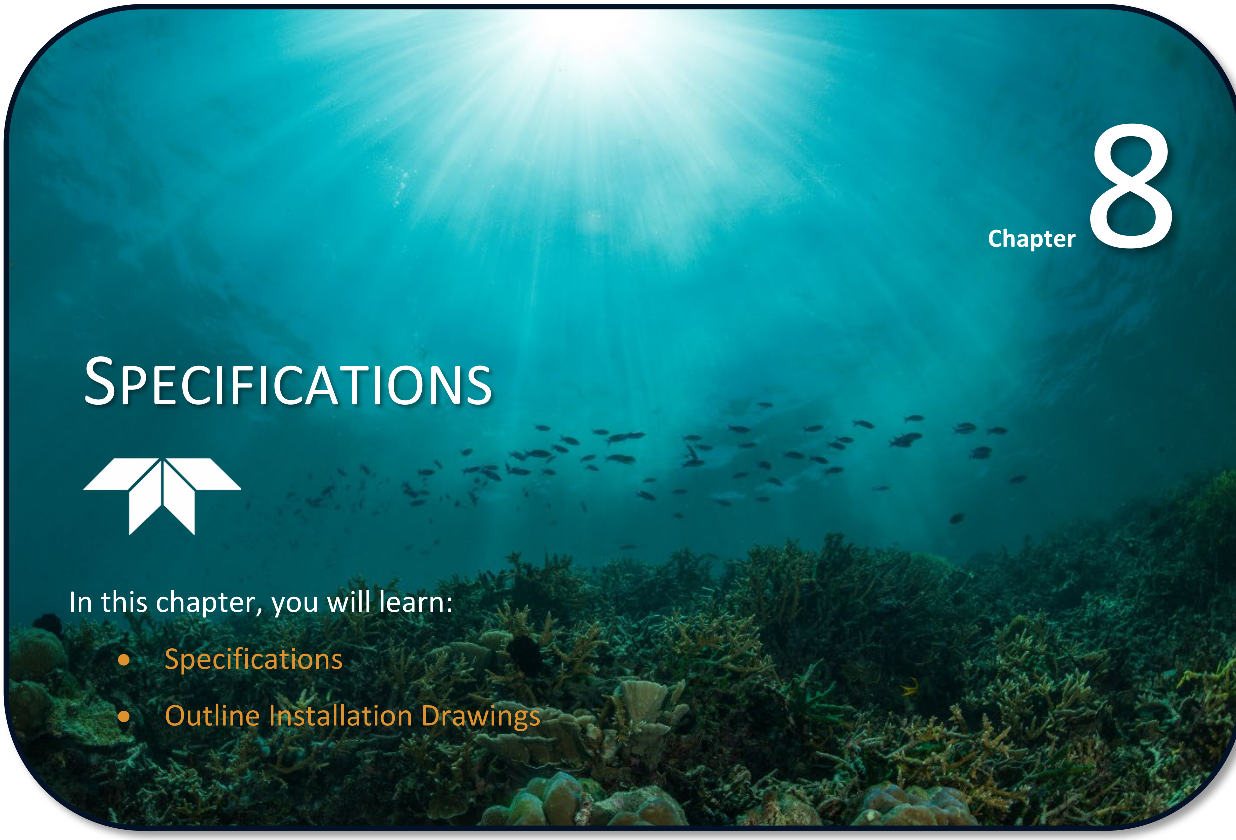
Step 5 - Send the Following Information by Telephone to TRDI

Attention: Sales Administration

Phone: +33(0) 492-110-930

- Detailed descriptions of what you are shipping (number of packages, sizes, weights and contents).
- The name of the freight carrier
- Master Air bill number
- Carrier route and flight numbers for all flights the package will take

NOTES



Chapter 8

SPECIFICATIONS

In this chapter, you will learn:

- Specifications
- Outline Installation Drawings

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

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

The ADCP emits an acoustic pulse called a PING. Scatterers that float ambiently with the water currents reflect some of the energy from the ping back to the ADCP. The ADCP uses the return signal to calculate a velocity. The energy in this signal is the *echo intensity*. Echo intensity is sometimes used to determine information about the scatterers.

The velocity calculated from each ping has a *statistical uncertainty*; however, each ping is an independent sample. The ADCP reduces this statistical uncertainty by averaging a collection of pings. A collection of pings averaged together is an *ensemble*. The ADCP's maximum *ping rate* limits the time required to reduce the statistical uncertainty to acceptable levels.

The ADCP does not measure velocity at a single point; it measures velocities throughout the water column. The ADCP 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 ADCP produces two profiles, one for velocity, and one for echo intensity.

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

The following tables list the specifications for the Workhorse II ADCP. About the specifications:

1. All these specifications assume minimal ADCP motion - pitch, roll, heave, rotation, and translation.
2. Except where noted, this specification table applies to typical set ups and conditions. Typical set ups 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 ADCP motion, and typical echo intensity levels.
3. The total measurement error of the ADCP is the sum of:
    - Long-term instrument error (as limited by instrument accuracy).
    - The remaining statistical uncertainty after averaging.
    - Errors introduced by measurement of ADCP heading and motion.
4. Because individual pings are independent, the statistical uncertainty of the measurement can be reduced according to the equation:

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

Table 20: Broad Bandwidth Water Profiling

Depth Cell Size[1]	Nominal range 15m[2] 1200 kHz			Nominal range 55m[2] 600 kHz			Nominal range 135m[2] 300k Hz		
Vertical Resolution	Range[3] (m)	Single Ping Std. dev. (cm/s)	Std. dev.[4] (cm/s)	Range[3] (m)	Single Ping Std. dev. (cm/s)	Std. dev.[4] (cm/s)	Range[3] (m)	Single Ping Std. dev. (cm/s)	Std. dev.[4] (cm/s)
0.25m	11.27	14.43	1.93						
0.50m	12.36	7.21	0.98	38.18	14.42	1.93			
1.0m	13.67	3.60	0.50	42.01	7.21	0.99	83.25	14.43	1.92
2.0m	15.12	1.80	0.24	46.49	3.60	0.51	92.62	7.21	0.98
4.0m				51.50	1.80	0.25	103.66	3.60	0.50
8.0m							116.10	1.81	0.24

NOTES
1. User's choice of depth cell size is not limited to the typical values specified.
2. Broad bandwidth mode is set with the WB command (WB0 by default).
3. Range, which depends on cell size, is specified here for Broad bandwidth mode at 5° C, typical ocean backscatter, and nominal 32 VDC battery power. Using 48 VDC will increase the range by 5 to 10% depending on conditions.
4. Broad bandwidth mode 50 water pings per ensemble standard deviation.
5. Table applies to Workhorse II Monitor/Sentinel/Mariner ADCPs.

Table 21: Narrow Bandwidth Water Profiling

Depth Cell Size[1]	Nominal range 15m[2] 1200 kHz			Nominal range 55m[2] 600 kHz			Nominal range 135m[2] 300 kHz		
Vertical Resolution	Range[3] (m)	Single Ping Std. dev. (cm/s)	Std. dev.[4] (cm/s)	Range[3] (m)	Single Ping Std. dev. (cm/s)	Std. dev.[4] (cm/s)	Range[3] (m)	Single Ping Std. dev. (cm/s)	Std. dev.[4] (cm/s)
0.25m	14.74	27.69	3.77						
0.50m	15.97	13.82	1.93	52.02	29.75	4.04			
1.0m	17.41	6.89	0.98	56.33	14.86	2.07	117.42	29.76	4.02
2.0m	18.96	3.45	0.48	61.27	7.40	1.06	128.11	14.86	2.05
4.0m				66.72	3.70	0.51	140.63	7.41	1.05
8.0m							154.39	3.72	0.52

NOTES
1. User's choice of depth cell size is not limited to the typical values specified.
2. Narrow bandwidth mode is set with the WB command (WB1).
3. Range, which depends on cell size, is specified here for Narrow bandwidth mode at 5° C, typical ocean backscatter, and nominal 32 VDC battery power. Using 48 VDC will increase the range by 5 to 10% depending on conditions.
4. Narrow bandwidth mode 50 water pings per ensemble standard deviation.
5. Table applies to Workhorse II Monitor/Sentinel/Mariner ADCPs.

Table 22: Workhorse II Range

Frequency	Range (m) @ 32VDC	Range (m) @ 48VDC	Depth Cell Size (m)
1200kHz	18.96	20.4	2
600kHz	66.72	70.9	4
300kHz	140.63	167.7	8

Range, which depends on cell size, is specified here for narrow bandwidth mode at 5° C, typical ocean backscatter, and nominal 32 VDC battery power (Sentinel) and 48VDC input power (Mariner/Monitor).

Table 23: Bottom Track Profile Parameters

System Frequency	1200 kHz	600 kHz	300 kHz
Maximum Altitude (m)*	28	100	260
Minimum Altitude (m)	0.8 (Mariner)	1.4 (Mariner)	2

* @ 48VDC input power.

Table 24: Bottom Track Velocity (for |V| < 10 m/s)

Precision (cm/s)*	1200 kHz	600 kHz	300 kHz
V=1.0 m/s	0.5	0.4	0.5
V=3.0 m/s	0.8	0.7	1.0
V=5.0 m/s	1.0	1.0	1.4
BT-BA (Base Accuracy) (cm/s)	±1.15% ± 0.4	±1.15% ± 0.4	±1.15% ± 0.4
BT-HA (High Accuracy) (cm/s)	±0.4% ± 0.4	±0.4% ± 0.4	±0.4% ± 0.4
Maximum Ping Rate**	1 to 10 Hz	0.5 to 7 Hz	0.5 to 7 Hz

* Water and Bottom velocity precision are standard deviations of horizontal velocities for single pings. The standard deviation for an ensemble of pings will decrease proportional to the square root of the number of pings averaged together.

* Single Ping Precision calculated for an altitude of one-half maximum altitude for a given frequency.

** Ping rates vary due to altitude, baud rate, and amount of water profiled.

BT-BA (Base Accuracy 1.15%) Bottom Track (Export-Compliant) and BT-HA (High Accuracy 0.4%) Bottom Track modes are mutually exclusive. Only one may be enabled.

Table 25: Profile Parameters

Item	Specification
Velocity accuracy	
1200 and 600 kHz	± 0.3% of the water velocity relative to the ADCP ± 3mm/s
300 kHz	± 0.5% of the water velocity relative to the ADCP ± 5mm/s
Velocity resolution	1 mm/s
Velocity range	± 5m/s (default), ± 20m/s (maximum)
Number of depth cells	1 to 255
Ping rate	2 Hz (typical)

Table 26: Echo Intensity Profile

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

Table 27: Standard Sensors

Temperature (Transducer Mounted)	
Range	-5° to 45° C
Uncertainty	±0.4° C
Resolution	0.01°
ISM Compass	
Heading Accuracy	1°RMS [Note 1]
Resolution	0.1°
ISM Tilt Sensors	
Range	±90°
Tilt Accuracy	±0.3° [Note 2]
Resolution	0.06°
Pressure Sensor	
Available Pressure Ratings	20 or 600 BAR
Short-term uncertainty	±0.1%
Max. drift	±0.25%

1. Heading Accuracy after Field Calibration: Calibration with >0.45 Gauss total field and <70° dip angle, ±70° combined tilt.
2. Long term Pitch/Roll Accuracy, <±70° combined tilt.

Table 28: Transducer and Hardware

Item	Specification
Beam angle	20°
Configuration	4 beams convex
Internal memory	Workhorse II ADCPs include one Delkin C600 series CompactFlash card, with the maximum memory capacity not to exceed 4GB per deployment.
Communications	Serial port selectable by switch for RS-232 or RS-422. ASCII or binary output at 1200 to 115,200 baud.

Table 29: Environmental Specifications

Item	Specification
Operating temperature with or without batteries	-5° to 45°C
Short Term Storage/Shipping (<45days) temperature (Batteries Installed)	-5° to 45°C
Long Term Storage (>45days) temperature (Batteries Installed)	O° C to 21° C
Long Term Storage (>45days) temperature (Batteries Removed)	-30° to 60°C
Long Term (>45days) Battery Storage	Batteries should be stored in cool dry air with a temperature range of O° C to 21° C
Battery Shelf Life	Use within one year

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

TRDI batteries have four dates on them:

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

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

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

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

*A battery pack used to start a deployment prior to the Warning Date means that it will perform as expected and provide the required power for any deployment that was created using the TRDI planning module. For example, if your deployment is going to be 12 months long and the battery label shows it is nine months old, it is safe to use the battery.

Table 30: Power

System	Specification
Sentinel	
DC input	20 to 50 VDC external power supply
Battery Voltage	42 VDC (new), 28 VDC (depleted)
Battery Capacity	450-watt hours @ 0° C
External Battery Pack	42 VDC (new), 28 VDC (depleted). Holds up to two 450-watt hour batteries
Transmit	16W @ 35V (1200kHz), 37W @ 35V (600kHz), 115W @ 35V (300kHz)
Monitor	
DC input	20 to 50 VDC external power supply or 42 VDC External Battery Pack
Transmit	22W @ 48V (1200kHz), 60W @ 48V (600kHz), 190W @ 48V (300kHz)
Mariner	
Deck Box Input	12 VDC, 20 to 50V DC external power supply, 110 to 220 VAC
Transmit	22W @ 48V (1200kHz), 60W @ 48V (600kHz), 190W @ 48V (300kHz)

Table 31. Lithium Battery Specifications

Temperature	Capacity (Whr)
0° C	1350
10° C	1500
20° C	1650
37° C	1450

Nominal voltage: 34 VDC

Weight: 2.8 kg

Self-discharge: 0.7%/year (10-year-old packs hold 93% of their original capacity)

Outline Installation Drawings

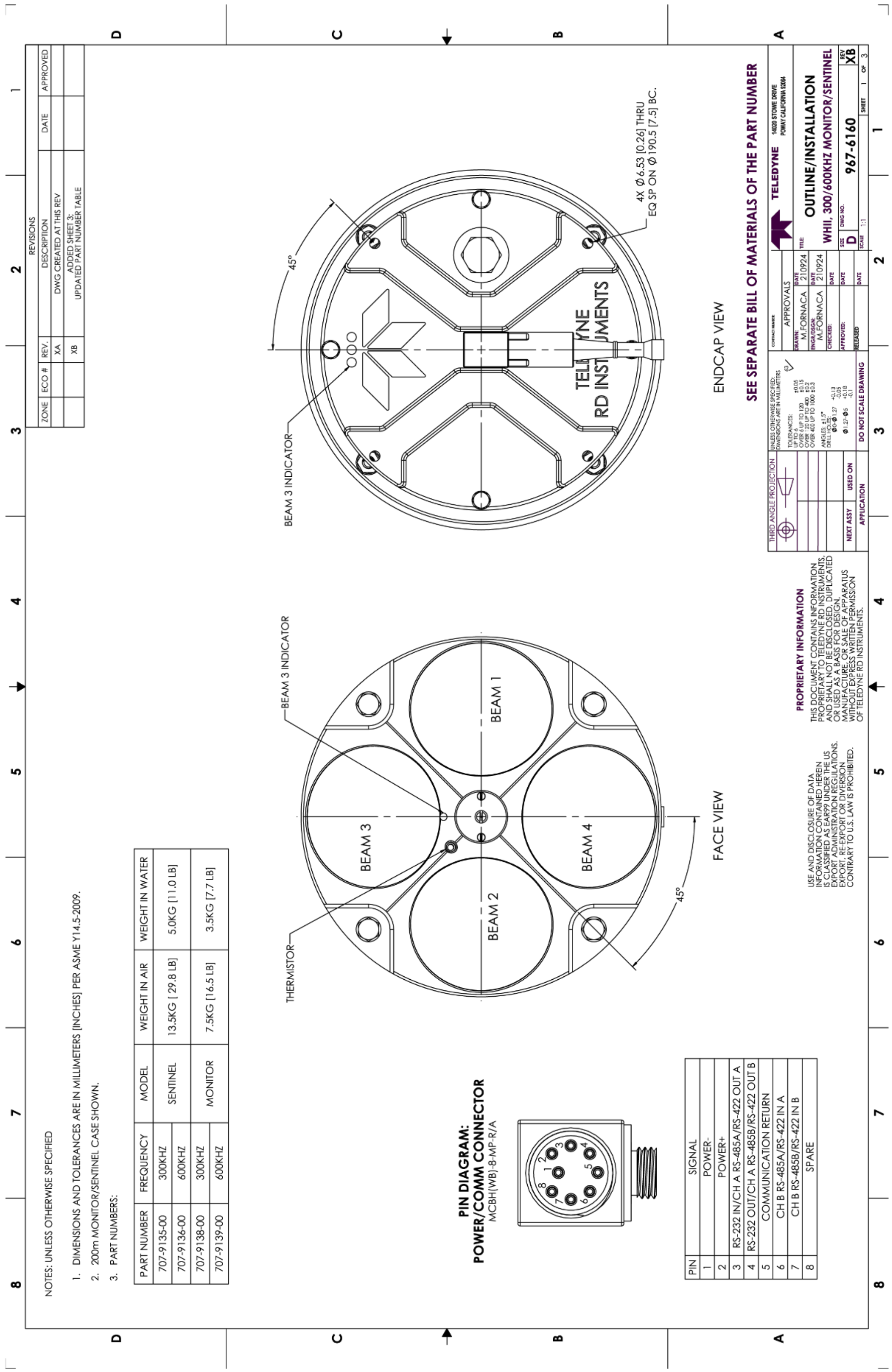
The following drawings show the Workhorse II Monitor, Sentinel, and Mariner Deck Box dimensions and weights.

Table 32: Outline Installation Drawings

Description	Drawing #	Revision
Workhorse II 300/600 kHz	967-6160	XB
Workhorse II 1200 kHz	967-6161	XC
Workhorse II 300/600 kHz 500 meter	TBD	TBD
Workhorse II 300/600 kHz Mariner	967-6164	XB
Mariner Deck Box	961-6031	C
External Battery Case	967-6162	XB

Outline Installation Drawings are subject to change without notice. Verify you have the latest version of the drawing by contacting TRDI before building mounts or other hardware.

967-6160


REVISIONS
ZONE | ECO # | REV. | DESCRIPTION | DATE | APPROVED
XA | DWG CREATED AT THIS REV
XB | ADDED SHEET 3; UPDATED PART NUMBER TABLE
NOTES: UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS AND TOLERANCES ARE IN MILLIMETERS [INCHES] PER ASME Y14.5-2009.
2. 200m MONITOR/SENTINEL CASE SHOWN.
3. PART NUMBERS:
PART NUMBER | FREQUENCY | MODEL | WEIGHT IN AIR | WEIGHT IN WATER
707-9135-00 | 300KHZ | SENTINEL | 13.5KG [29.8 LB] | 5.0KG [11.0 LB]
707-9136-00 | 600KHZ
707-9138-00 | 300KHZ | MONITOR | 7.5KG [16.5 LB] | 3.5KG [7.7 LB]
707-9139-00 | 600KHZ
PIN DIAGRAM: POWER/COMM CONNECTOR
MCBH(WB)-8-MP-R/A
PIN | SIGNAL
1 | POWER-
2 | POWER+
3 | RS-232 IN/CH A RS-485A/RS-422 OUT A
4 | RS-232 OUT/CH A RS-485B/RS-422 OUT B
5 | COMMUNICATION RETURN
6 | CH B RS-485A/RS-422 IN A
7 | CH B RS-485B/RS-422 IN B
8 | SPARE
THERMISTOR
BEAM 3 INDICATOR
BEAM 1
BEAM 2
BEAM 3
BEAM 4
45°
FACE VIEW
ENDCAP VIEW
4X Ø 6.53 [0.26] THRU
EQ SP ON Ø 190.5 [7.5] BC.
TELEDYNE RD INSTRUMENTS
SEE SEPARATE BILL OF MATERIALS OF THE PART NUMBER
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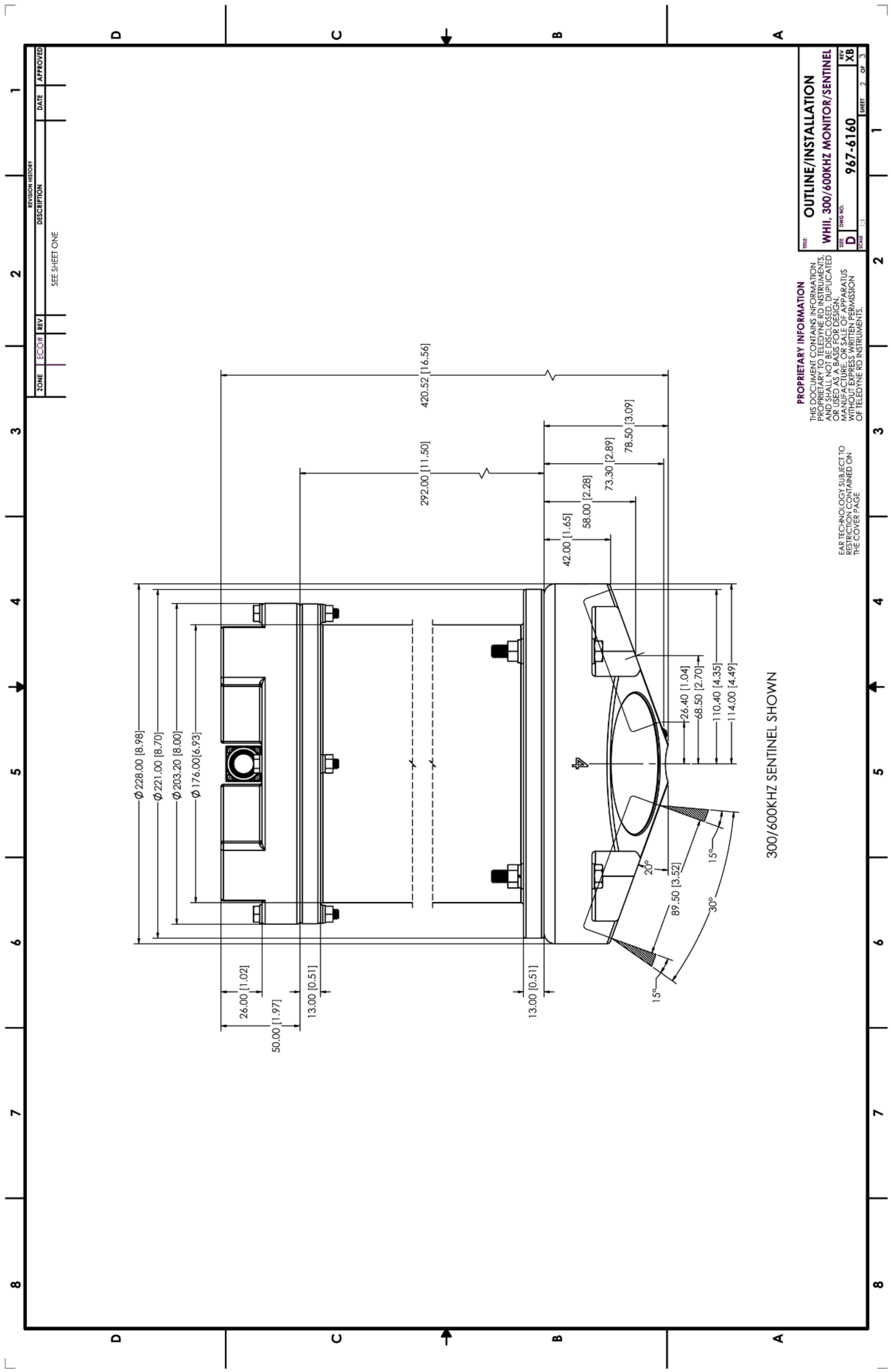
DRAWN M.FORNACA 210924
ENGR DESIGN M.FORNACA 210924
TELEDYNE 14020 STOWE DRIVE POWAY CALIFORNIA 92064
OUTLINE/INSTALLATION
WHII, 300/600KHZ MONITOR/SENTINEL
SIZE D DWG NO. 967-6160 REV XB
SCALE 1:1 SHEET 1 OF 3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WHII, 300/600KHZ MONITOR/SENTINEL
967-6160
300/600KHZ SENTINEL SHOWN
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73.30 [2.89]
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Ø 176.00[6.93]
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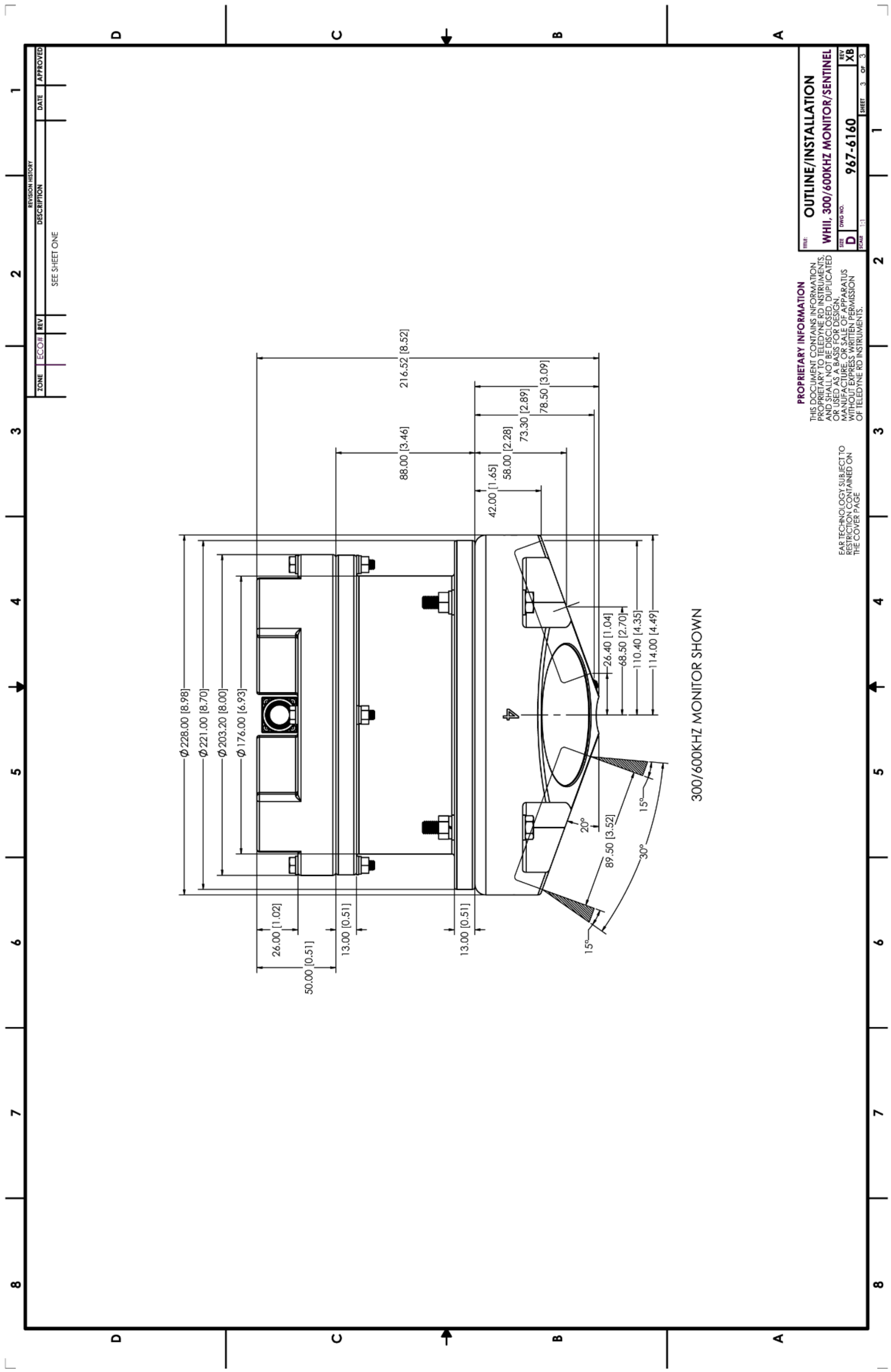
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WHII, 300/600KHZ MONITOR/SENTINEL
967-6160
SIZE D
REV XB
SCALE 1:1
SHEET 3 OF 3
PROPRIETARY INFORMATION
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REVISION HISTORY
ZONE
ECO#
REV
DESCRIPTION
DATE
APPROVED
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300/600KHZ MONITOR SHOWN
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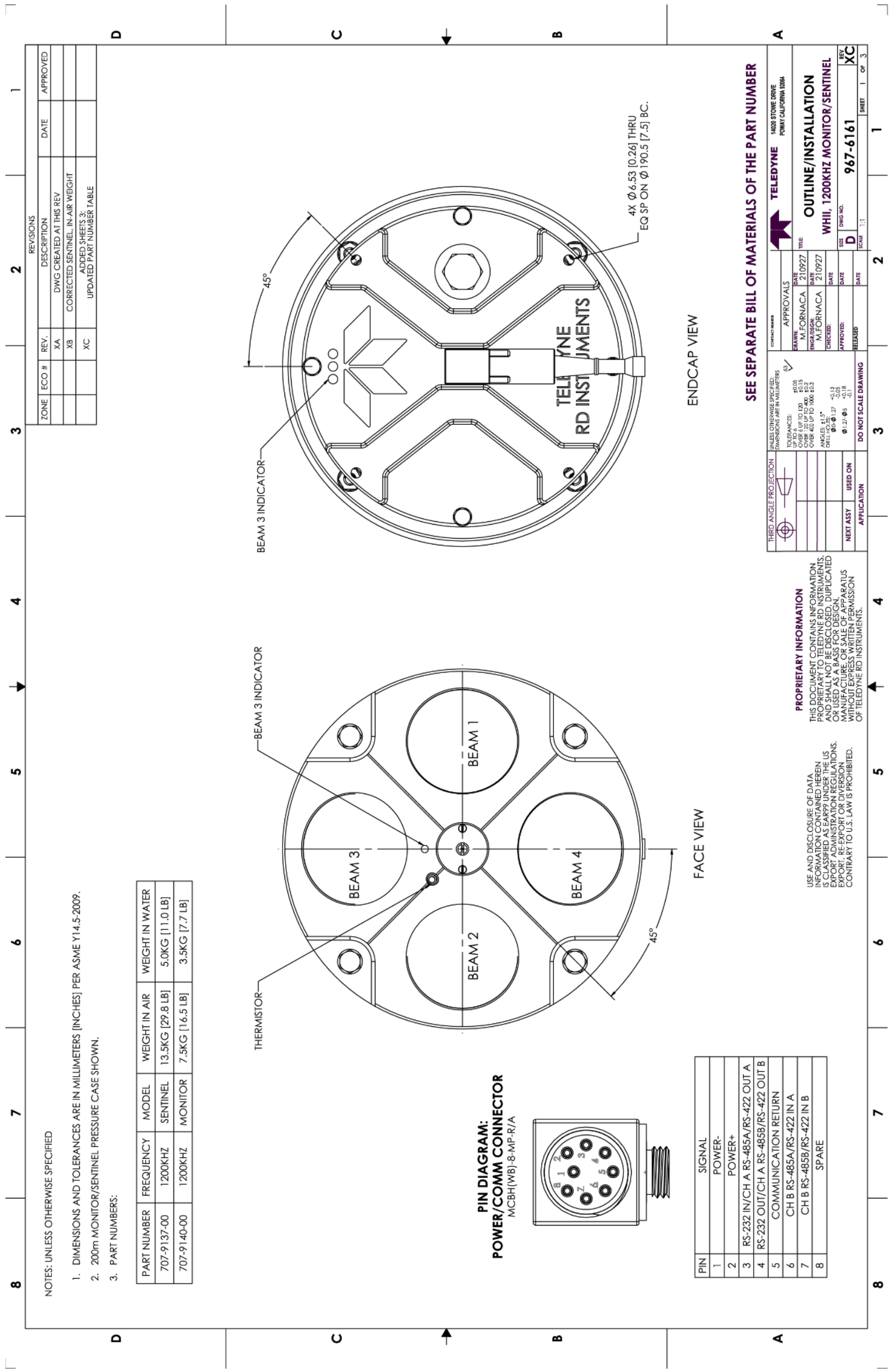
967-6161


NOTES: UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS AND TOLERANCES ARE IN MILLIMETERS [INCHES] PER ASME Y14.5-2009.
2. 200m MONITOR/SENTINEL PRESSURE CASE SHOWN.
3. PART NUMBERS:
PART NUMBER | FREQUENCY | MODEL | WEIGHT IN AIR | WEIGHT IN WATER
707-9137-00 | 1200KHZ | SENTINEL | 13.5KG [29.8 LB] | 5.0KG [11.0 LB]
707-9140-00 | 1200KHZ | MONITOR | 7.5KG [16.5 LB] | 3.5KG [7.7 LB]
PIN DIAGRAM:
POWER/COMM CONNECTOR
MCBH(WB)-8-MP-R/A
PIN | SIGNAL
1 | POWER-
2 | POWER+
3 | RS-232 IN/CH A RS-485A/RS-422 OUT A
4 | RS-232 OUT/CH A RS-485B/RS-422 OUT B
5 | COMMUNICATION RETURN
6 | CH B RS-485A/RS-422 IN A
7 | CH B RS-485B/RS-422 IN B
8 | SPARE
THERMISTOR
BEAM 3 INDICATOR
BEAM 1
BEAM 2
BEAM 3
BEAM 4
45°
FACE VIEW
BEAM 3 INDICATOR
45°
4X Ø6.53 [0.26] THRU
EQ SP ON Ø190.5 [7.5] BC.
ENDCAP VIEW
REVISIONS
ZONE | ECO # | REV. | DESCRIPTION | DATE | APPROVED
	XA	DWG CREATED AT THIS REV	
	XB	CORRECTED SENTINEL IN-AIR WEIGHT	
	XC	ADDED SHEETS 3; UPDATED PART NUMBER TABLE	
SEE SEPARATE BILL OF MATERIALS OF THE PART NUMBER
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APPLICATION
DO NOT SCALE DRAWING
APPROVALS
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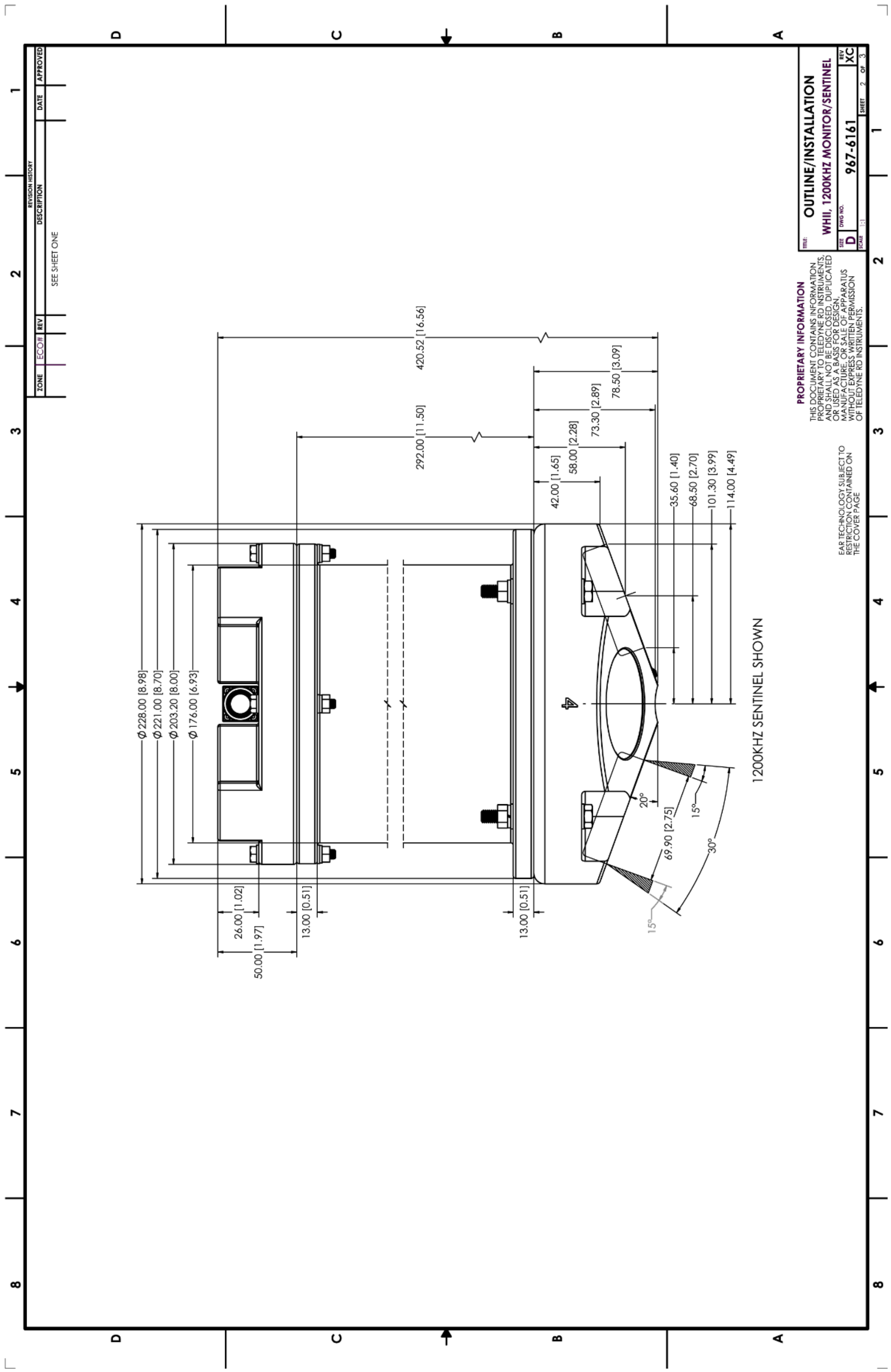
ENGINEERING: M.FORNACA 210927
CHECKED
APPROVED
RELEASED
TELEDYNE
14020 STOWE DRIVE POWAY CALIFORNIA 92064
OUTLINE/INSTALLATION
WHII, 1200KHZ MONITOR/SENTINEL
SIZE D
DWG NO. 967-6161
REV XC
SCALE 1:1
SHEET 1 OF 3



OUTLINE/INSTALLATION
WHII, 1200KHZ MONITOR/SENTINEL
967-6161
1200KHZ SENTINEL SHOWN
SEE SHEET ONE
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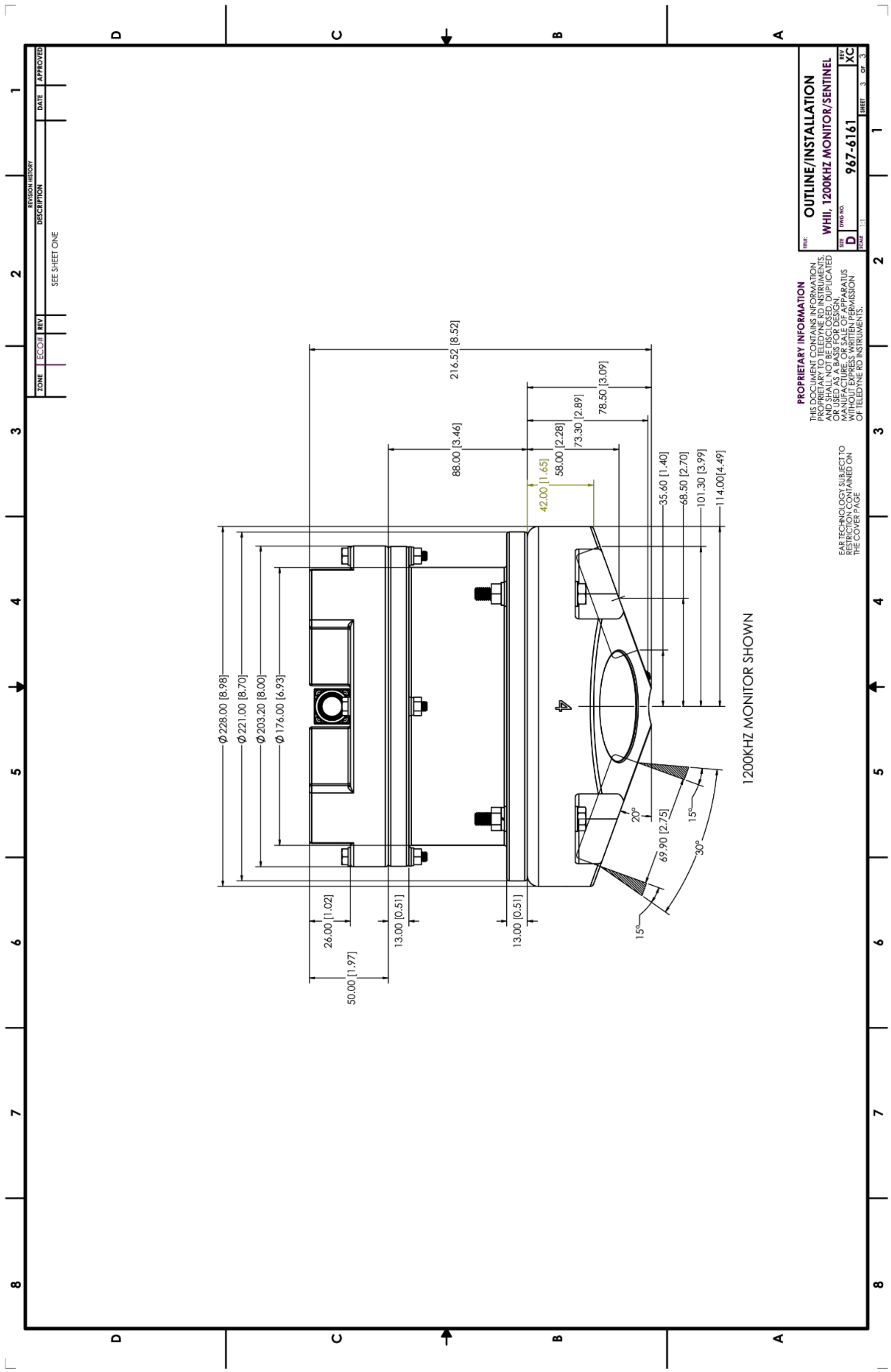
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WHII, 1200KHZ MONITOR/SENTINEL
967-6161
1200KHZ MONITOR SHOWN
PROPRIETARY INFORMATION
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Ø 221.00 [8.70]
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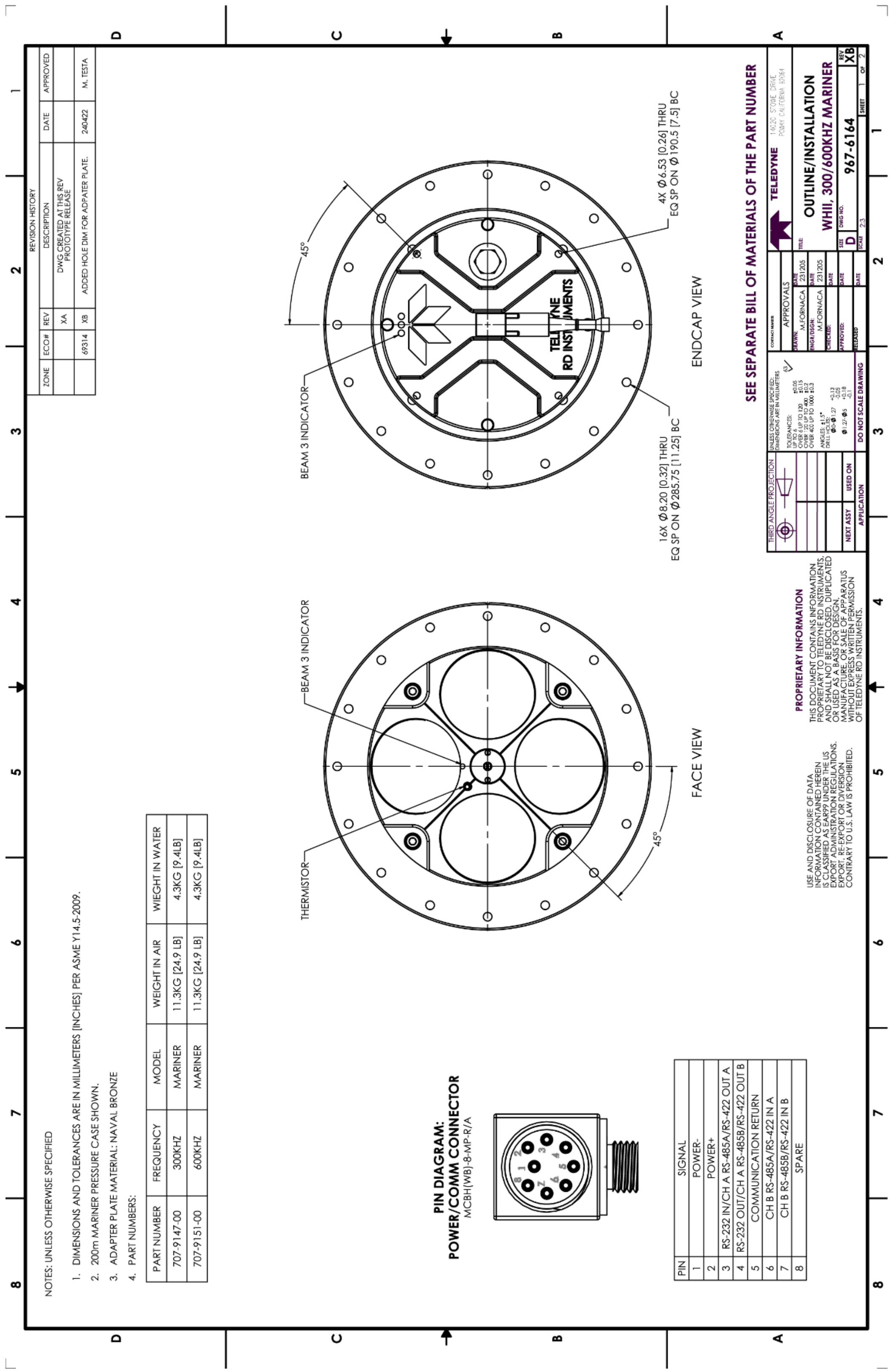
967-6164


NOTES: UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS AND TOLERANCES ARE IN MILLIMETERS [INCHES] PER ASME Y14.5-2009.
2. 200m MARINER PRESSURE CASE SHOWN.
3. ADAPTER PLATE MATERIAL: NAVAL BRONZE
4. PART NUMBERS:
PART NUMBER | FREQUENCY | MODEL | WEIGHT IN AIR | WEIGHT IN WATER
707-9147-00 | 300KHZ | MARINER | 11.3KG [24.9 LB] | 4.3KG [9.4LB]
707-9151-00 | 600KHZ | MARINER | 11.3KG [24.9 LB] | 4.3KG [9.4LB]
PIN DIAGRAM:
POWER/COMM CONNECTOR
MCBH(WB)-8-MP-R/A
PIN | SIGNAL
1 | POWER-
2 | POWER+
3 | RS-232 IN/CH A RS-485A/RS-422 OUT A
4 | RS-232 OUT/CH A RS-485B/RS-422 OUT B
5 | COMMUNICATION RETURN
6 | CH B RS-485A/RS-422 IN A
7 | CH B RS-485B/RS-422 IN B
8 | SPARE
THERMISTOR
BEAM 3 INDICATOR
FACE VIEW
45°
ENDCAP VIEW
TELEDYNE RD INSTRUMENTS
4X Ø6.53 [0.26] THRU
EQ SP ON Ø190.5 [7.5] BC
16X Ø8.20 [0.32] THRU
EQ SP ON Ø285.75 [11.25] BC
REVISION HISTORY
ZONE | ECO# | REV | DESCRIPTION | DATE | APPROVED
XA | DWG CREATED AT THIS REV PROTOTYPE RELEASE
69314 | XB | ADDED HOLE DIM FOR ADPATER PLATE. | 240422 | M. TESTA
SEE SEPARATE BILL OF MATERIALS OF THE PART NUMBER
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APPLICATION
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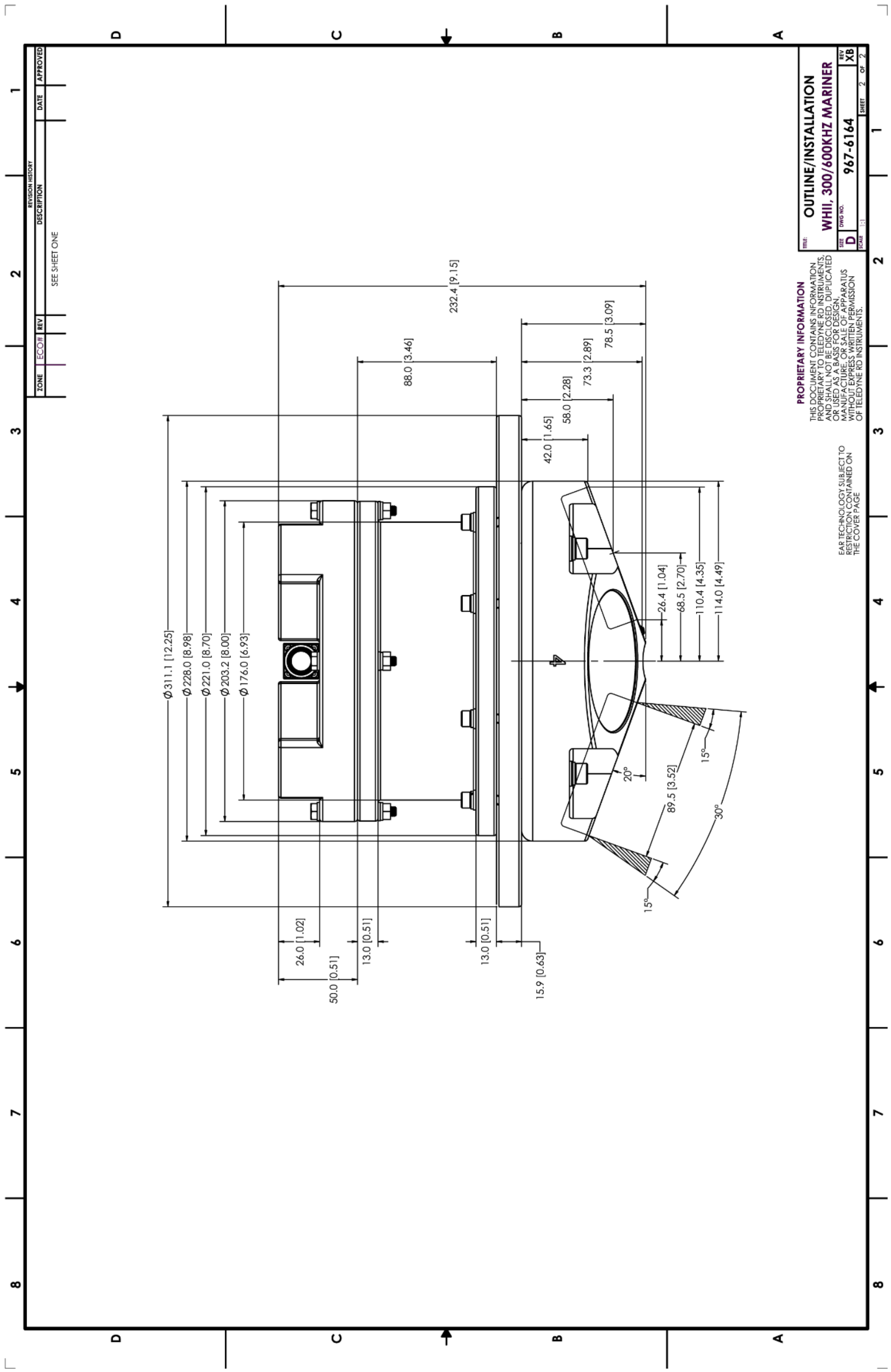
APPROVALS
DRAWN M.FORNACA 231205
ENGR/DESIGN M.FORNACA 231205
TELEDYNE
OUTLINE/INSTALLATION
WHII, 300/600KHZ MARINER
SIZE D
DWG NO. 967-6164
REV XB
SCALE 2:3
SHEET 1 OF 2


OUTLINE/INSTALLATION
WHII, 300/600KHZ MARINER
967-6164
SEE SHEET ONE
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EAR TECHNOLOGY SUBJECT TO RESTRICTION CONTAINED ON THE COVER PAGE
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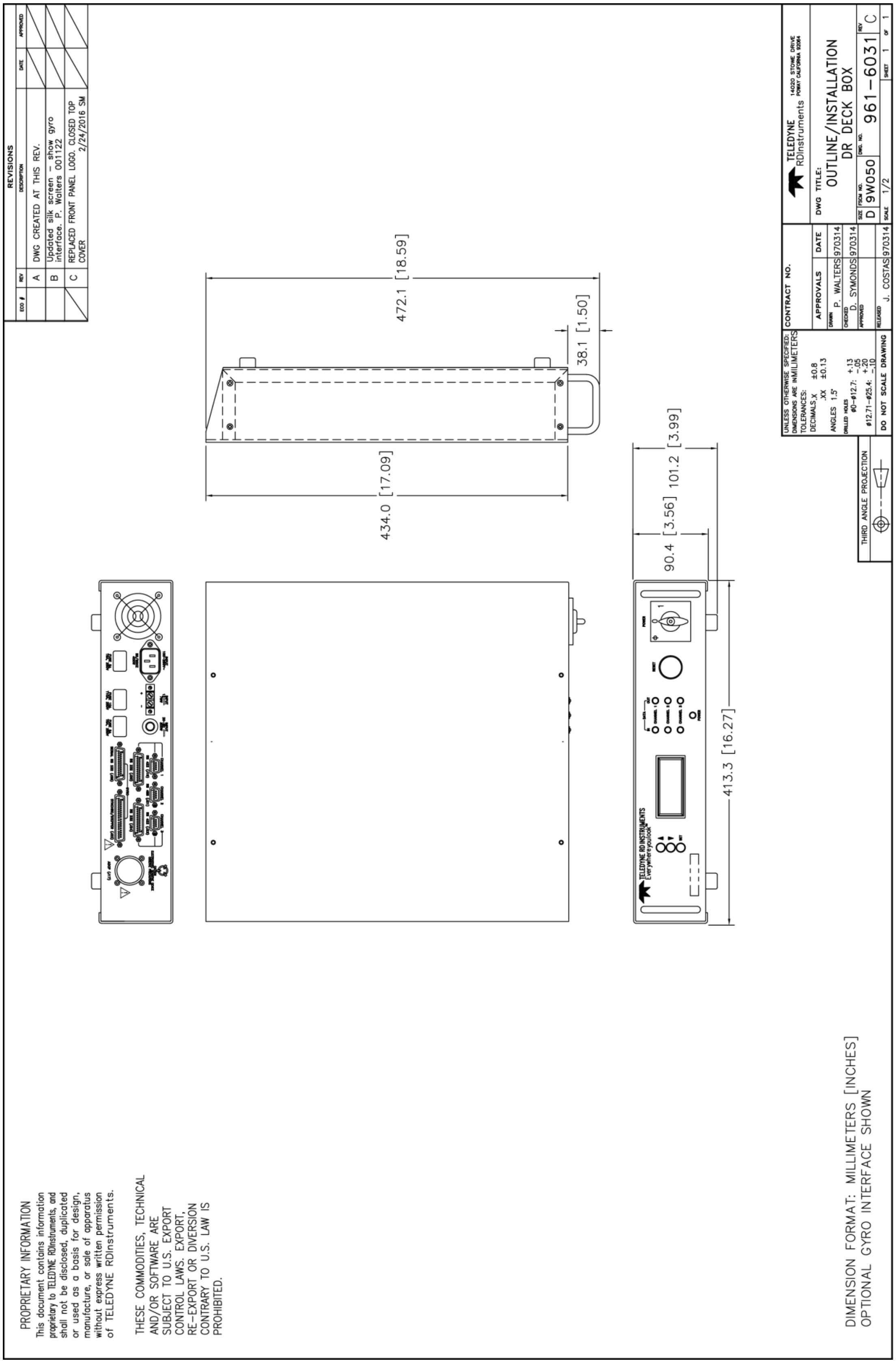
961-6031


REVISIONS
A DWG CREATED AT THIS REV.
B Updated silk screen – show gyro interface. P. Walters 001122
C REPLACED FRONT PANEL LOGO, CLOSED TOP COVER 2/24/2016 SM
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38.1 [1.50]
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90.4 [3.56]
101.2 [3.99]
413.3 [16.27]
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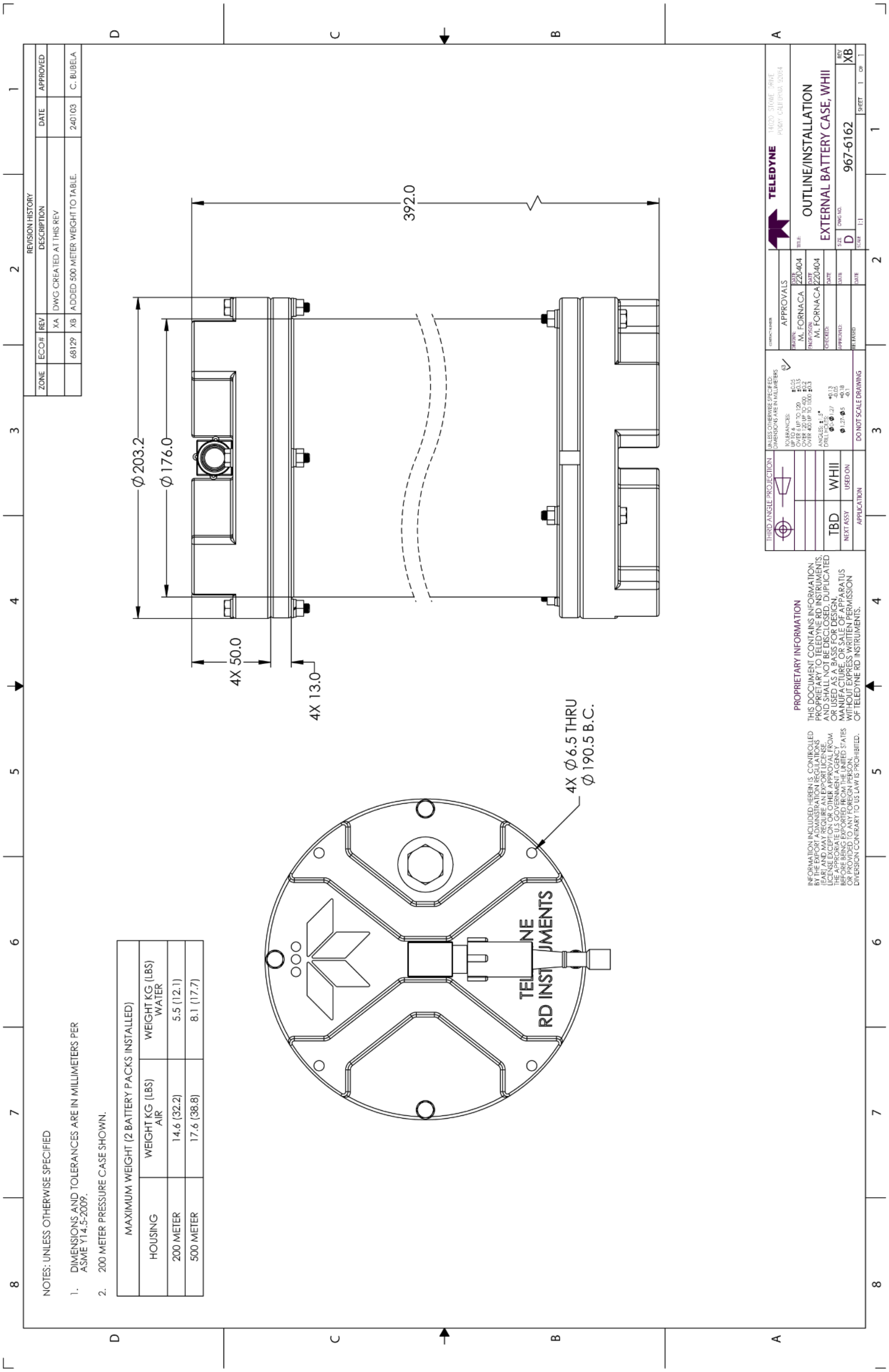
DIMENSION FORMAT: MILLIMETERS [INCHES]
OPTIONAL GYRO INTERFACE SHOWN
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING
P. WALTERS 970314
D. SYMONDS 970314
J. COSTAS 970314
TELEDYNE RDInstruments
DWG TITLE: OUTLINE/INSTALLATION DR DECK BOX
D 9W050 961-6031 C
SCALE 1/2 SHEET 1 OF 1

967-6162



REVISION HISTORY
ZONE | ECO# | REV | DESCRIPTION | DATE | APPROVED
XA | DWG CREATED AT THIS REV
68129 | XB | ADDED 500 METER WEIGHT TO TABLE. | 240103 | C. BUBELA
392.0
Ø203.2
Ø176.0
4X 50.0
4X 13.0
4X Ø6.5 THRU
Ø190.5 B.C.
NOTES: UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS AND TOLERANCES ARE IN MILLIMETERS PER ASME Y14.5-2009.
2. 200 METER PRESSURE CASE SHOWN.
MAXIMUM WEIGHT (2 BATTERY PACKS INSTALLED)
HOUSING | WEIGHT KG (LBS) AIR | WEIGHT KG (LBS) WATER
200 METER | 14.6 (32.2) | 5.5 (12.1)
500 METER | 17.6 (38.8) | 8.1 (17.7)
PROPRIETARY INFORMATION
TELEDYNE
OUTLINE/INSTALLATION
EXTERNAL BATTERY CASE, WHII
967-6162
M. FORNACA 220404
TBD
WHII
DO NOT SCALE DRAWING
THIRD ANGLE PROJECTION
D
XB

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 33.

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 33. 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	X	O	X	O	O
接收机电路板/数据处理器电路板 Receiver PCB/ DSP PCB	O	O	O	O	O	O
微处理器电路板/输入输出口电路板 CPU PCB/PIO PCB	O	O	O	O	O	O
机体装配 Housing Assy.	O	O	O	O	O	O
底座装配 End-Cap Assy.	O	O	O	O	O	O
电池组 Battery Pack	O	O	O	O	O	O
交流电转换器 AC Voltage Adapter	O	O	O	O	O	O
水下专用电缆 Underwater Cable	O	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 。

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