Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedures for Calibration, Preparation, and Deployment of Teledyne RD Instruments Acoustic Doppler Current Profilers (ADCPs) © (RDI)

Version 1.1

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EAP050

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Please note that the Washington State Department of Ecology's Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical and administrative experts. Their primary purpose is for internal Ecology use, although sampling and administrative SOPs may have a wider utility. Our SOPs do not supplant official published methods. Distribution of these SOPs does not constitute an endorsement of a particular procedure or method.

Any reference to specific equipment, manufacturer, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the author or by the Department of Ecology.

Although Ecology follows the SOP in most instances, there may be instances in which Ecology uses an alternative methodology, procedure, or process.

SOP Revision History

Revision Date	Rev	Summary of changes	Sections	Reviser
7/17/2013	1.0	Minor changes		
5/1/2016	1.1	Added details of DOT ferry-mounted ADCPs.	6 & 7	Jim T/ Skip A
5/1/2016	1.1	Recertified	All	Kammin

Environmental Assessment Program

Standard Operating Procedure for Calibration, Preparation, and Deployment of Teledyne RD Instruments (© RDI) ADCPs.

1.0 Purpose and Scope

1.1 This document is the Environmental Assessment Program (EAP) Standard Operating Procedure (SOP) for calibrating, preparing, deploying, and recovering fixed-point submerged (e.g., bottom-mounted) and vessel (surface-mounted) acoustic Doppler current profilers (ADCPs) in coastal and inland marine waters (e.g., Puget Sound) of Washington State. ADCP current meters allow Ecology to directly measure water velocity that can be used to calculate fluxes of constituents that may be important to regulation of water quality in the marine waters of Washington State.

Figure 1. Workhorse Sentinel 300 kHz ADCP.

This document also covers the installation of ADCPs on ferry vessels. In this case, the instrument is permanently mounted to the hull of a ferry and used to measure profiles of water velocity during the regular crossings at key locations in Puget Sound, such as Admiralty Reach (Keystone-Coupeville route). The profiles of velocity can be used to estimate the exchange of ocean water with Puget Sound water, provided that the data are collected regularly over long time windows so that the tides can be averaged out of the results.

1.2 Basic Theory of Operation

1.2.1 The ADCP operates by transmitting bursts of sound (called pings) at fixed intervals and frequency into the water column. These “pings” are reflected from suspended particles in the water and the echoes produced from these reflections are received (“listened” to) by the ADCP. As the particles move with the water current the echoes produce a Doppler shift or a change in the frequency between the transmitted sound and the sound reflected back to the ADCP. It is the Doppler shift along with the timing of the returned echoes from which the ADCP calculates water velocity, current direction, and the depth within the water column the velocity occurred. The ADCP also produces a longer-pulsed ping which is used to track the seafloor in the case of downward pointed vessel-

mounted applications. This is used to determine the overall depth of the water column and to determine the relative speed and direction of the ADCP as it moves along a transect.

1.2.2 All of these data are calculated and recorded within the ADCP itself or transmitted via cable to a laptop computer. The data are stored in files and can be "played back" and post-processed allowing the user to refine the data. Details of the fixed-point (e.g., bottom) and vessel (surface) mounted deployments are somewhat different, and are subsequently treated separately below.

1.3 Limitations of Use

1.3.1 Although the ADCP greatly enhances the Marine Monitoring Unit's (MMU) ability to measure water velocity in most circumstances, there are certain situations that will limit or preclude its use. The ADCP requires a minimum water depth of several meters to operate. Likewise there is a limiting range (e.g., a 300 kHz ADCP can measure a range of about 150m) above which the energy of the returned sound is too small to be useful. The lower the frequency of the ADCP (e.g., a 150 kHz ADCP is lower than a 600 kHz unit), the greater the range of penetration for a tradeoff in resolution. There is a "blanking" distance of several meters nearest to the ADCP from which no data can be returned. This is because the transducer cannot recover instantaneously from sending a ping before it is ready to receive returns. A fixed-point upward looking ADCP will also lose some data near the sea-surface due to side lobe interference.

Table 1. ADCP capability by transducer type.

Water Profiling	1200 kHz	600 kHz	300 kHz
Cell Size (m)	Typical Range 12m	Typical Range 50m	Typical Range 110m
.25	11-14		
.5	13-16	39	
1	14-18	43	71-92
2	15-20	47	78-102
4		52	86-113
8			95-126

1.3.2 A downward-looking ADCP requires the seafloor bottom to be stable with no bed movement during the measurement for vessel-mounted applications. The reason for this is the ADCP orients itself with respect to its own rotation (pitch, roll and heading) and translation (vessel velocity across the water) to the seafloor bottom and measures currents relative to the ADCP. Bottom tracking is a feature of the ADCP that allows for the orientation of the ADCP and the subsequent corrections of data due to the relative motion of the ADCP. If there is a moving bed, the ADCP will not be able to correctly measure vessel velocity and direction which, in turn, will eliminate its ability to accurately measure current velocity. Moving beds in Puget Sound are unusual

2.0 Applicability

This SOP should be followed for calibrating, preparing, deploying, and recovering ADCPs utilized in marine monitoring for the WA Department of Ecology. It includes the approved methods for any of the following:

2.1 This procedure is to be used when deploying an ADCP on the seafloor with a battery for power. Preparation for deployment should be planned with Teledyne RD Instrument's PlanADCP software so that battery life and data storage issues are properly addressed.

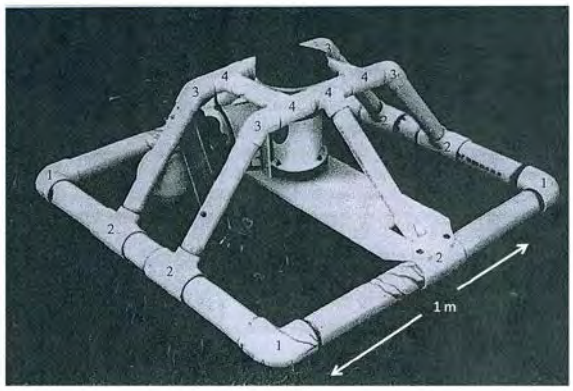
The ADCP has no moving parts, but it contains internal sensors that are sensitive to electromagnetic fields. Understanding these interactions as well as depth-limiting aspects both to the package and the recovery of the instrument is important for a successful installation. Calibration to remove one- and two-cycle magnetic deviations from the internal magnetic fluxgate compass after adding a new battery should be followed using the methods as called for in Teledyne RD Instrument's instruction manual.

2.2 Procedure is to be used when temporarily mounting an ADCP on the R/V Skookum or on similar vessels used by Ecology. Vessels have their own magnetic field and there must be compensation for compass deviation in the results.

2.3 Procedure is also to be followed when installing an ADCP permanently, via a thru-hull "sea chest", on any vessel. Vessels have their own magnetic field and there must be compensation for compass deviation in the results.

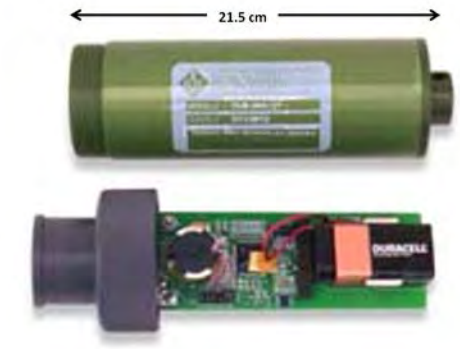
Definitions

a)



b)

c)



d)

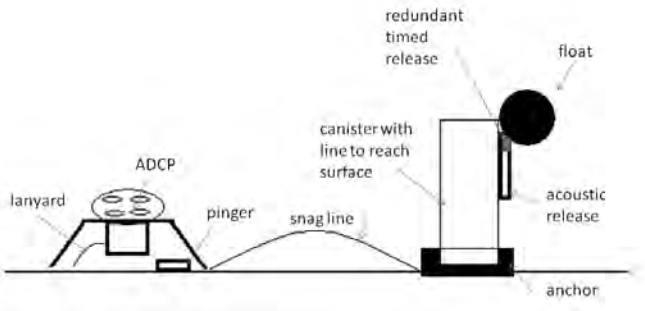


Figure 2. ADCP recovery system: a) seafloor mount, b) acoustic release, c) pinger, and d) detailed configuration for on-bottom deployment.

3.0 ADCP is an Acoustic Doppler Current Profiler, which uses sonar pulses to measure velocity at different distances, or range “bins”, extending from the instrument.

3.1 Fixed-mount -- any application consisting of an ADCP unit that is designed to sample below the water surface for an extended period of time at a fixed location either attached to a mount on the seafloor or on a fixed surface such as a piling. Typical sensors consist of four send-and-receive Doppler transducers – three for measuring velocity (u, v, and w) with one redundant transducer for error checking, a temperature cell, a tilt sensor, a fluxgate compass, and an optional pressure transducer. These units are typically mounted in a weighted PVC cage, tethered with a lanyard, and outfitted with a multi-mode recovery system - acoustic releases (Benthos Model 875-A), pingers

(RJE Model ULB-364/37), and a last resort snag-line (Figure 2). The present configuration allows deployment down to a depth of approximately 40m (e.g., at low tide), which is also a depth at which recovery via the snag-line or with conventional SCUBA becomes difficult. The pinger is an aid to recovery for SCUBA divers, and the snag-line can be grasped from the surface with the aid of a grappling hook. Normal recovery is accomplished with the aid of an acoustic release, which can be tripped with a hydrophone from the surface to release a buoyant vinyl ("Viny") float with a line attached. In addition, a time-out release (e.g., www.subseasonics.com/trelease.htm) is recommended as a back-up, especially on deployments deeper than 30m.

Figure 3. ADCP mounted on R/V Skookum (secured with redundant lanyard).

3.2 Vessel-mount: any application consisting of an ADCP that is attached to a moving platform (i.e., a boat). The package consists of four Doppler transducers (send and receive) – three for measuring velocity (u, v, and w) and one for error checking, a temperature cell, a tilt sensor, a fluxgate compass, in addition the ADCP should have bottom-tracking engaged (Fig. 3).

3.2.1 For the Skookum, the ADCP is secured to a mounting pole with two hose clamps and a back-up lanyard. In addition, the laptop collecting results from the ADCP via a powered cable, can also receive GGA-mode (or GSA-mode) data sentences from a differential GPS.

3.3 For the ferries, the ADCP is mounted in a "sea chest", which is the housing on the hull of the vessel below the water line that allows the instrument to have a clear acoustic path to the water below the vessel. This, by definition is a "thru-hull" fitting, because it penetrates the vessel hull. The sea chest protrudes from the hull and the lower section is filled with fresh water to improve acoustic transmission.

3.3.1 NMEA data are the National Marine Electronics Associated standard format for sending navigational data, as collected by a Global Positioning System (GPS), such as vessel latitude, longitude, and speed over ground (SOG), and true heading (HDT).

4.0 Personnel Qualifications/Responsibilities

4.1 This type of field servicing typically requires two technicians to safely perform in addition to the boat operator, preferably with 2+ years of related experience. Personnel should be experienced in the operation of ADCP instruments and in general data acquisition using serial communications. Training in the use of ADCP equipment and software as well as experience with water sampling. Training in safety procedures for working on floating structures and near/over open water and on boats as well as experience working with hazardous chemicals (anti-foul paint on ADCP transducer heads).

4.2 Specific training for working on Ecology vessels may apply.

4.3 Ferry access may require that personnel must have Transportation Worker Identification Cards (TWIC) for working in secure areas on ferry vessels and in shipyards.

5.0 Equipment, Reagents, and Supplies

Standard safety equipment includes approved life jackets and foul weather gear. Some vessels may require hard hats. Several sets of Nitrile, leather, and neoprene gloves may be necessary as well depending on whether anti-fouling chemicals have been used or if winch operations require it.

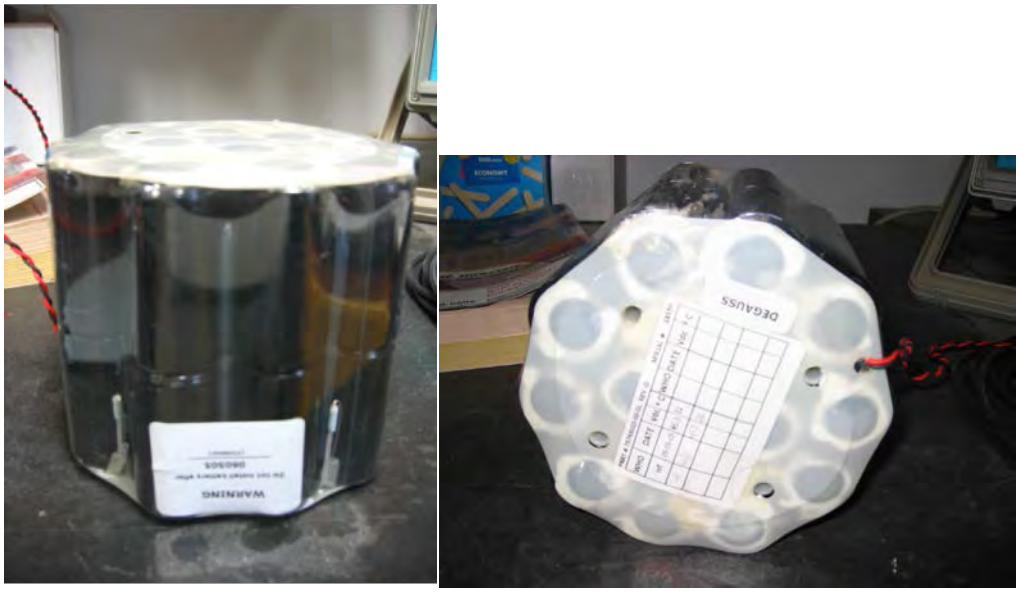


Figure 4. Fresh battery pack for fixed- or bottom-mount deployment.

5.1 For fixed-mount deployments (details listed in Appendix E):

- 5.1.1 De-Gaussed ADCP battery pack (Fig. 4)
- 5.1.2 Calibration equipment (lap top, cables, non-magnetic lazy Susan, and tilting block)
- 5.1.3 Dedicated laptop, unless starting data acquisition beforehand after calibration
- 5.1.4 Mounts, shackles, tackle, and recovery system
- 5.1.5 Field Logs (Appendix A)
- 5.1.6 Checklist and ADCP packer box with tools from OC (appendix)
- 5.1.7 Recovery line and tackle (station dependent)

5.2 For Skookum-mount deployments (details listed in Appendix D):

- 5.2.1 Dedicated laptop computer equipped with ADCP software
- 5.2.2 Interface for DGPS from ship (if desired)
- 5.2.3 ADCP communication cables, power cord
- 5.2.4 Field Logs (Appendix B)
- 5.2.5 Checklist and ADCP packer box with tools from OC (appendix)

5.3 For ferry-mount deployments:

System schematic and components/parts list are shown in Figure 5. There are no toxic materials. This assumes that a licensed shipyard has fabricated the sea-chest thru-hull mount for the vessel.

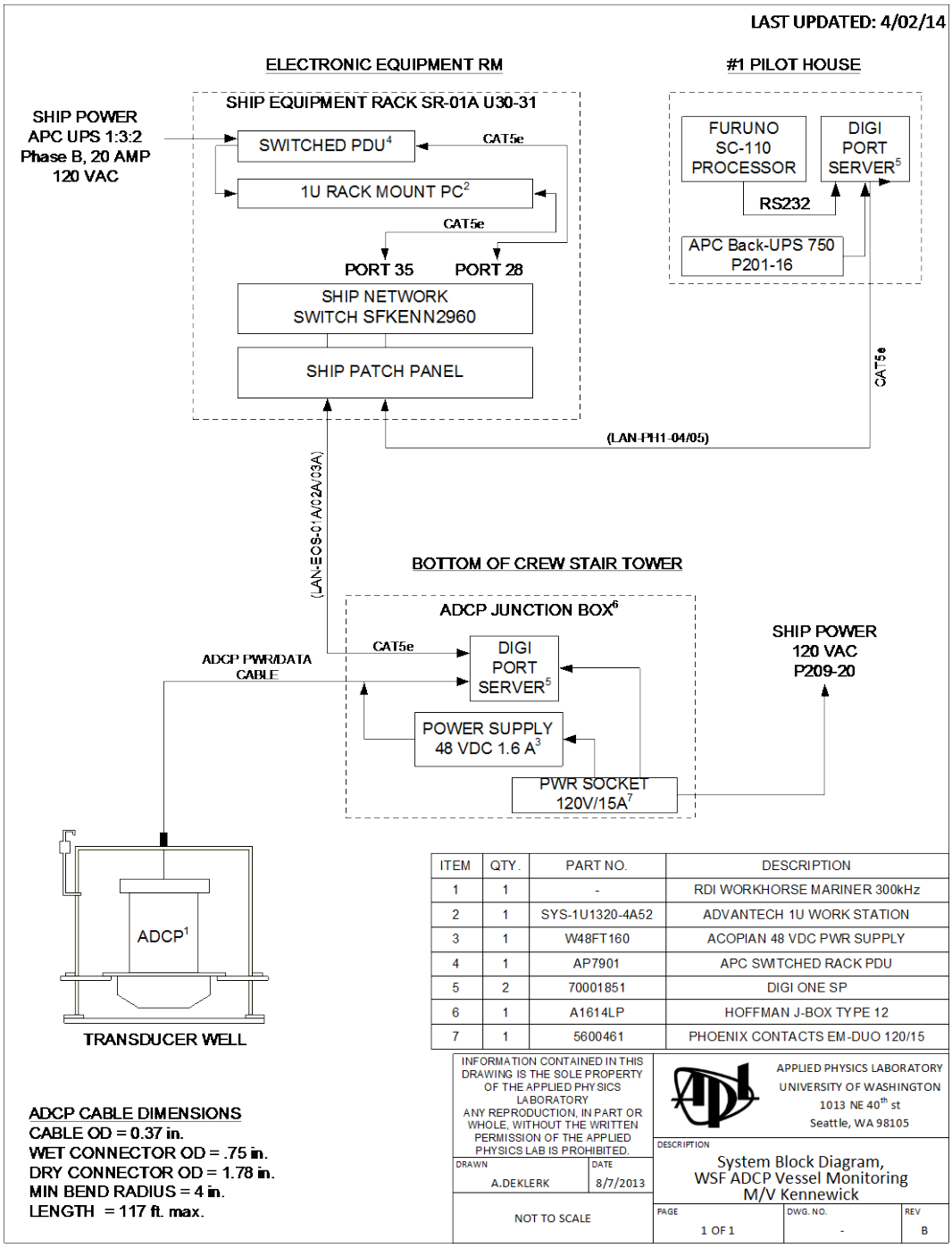


Figure 5. System schematic and components list for ferry operations.

6.0 Summary of Procedure

6.1 Trip Preparation

Prepare a field/float plan before embarking (Appendix C), located on the Ecology SharePoint site. Load vehicle according to the type of deployment (e.g., fixed on bottom) and use the corresponding checklist (Appendices D, E).

6.2 Fixed-mount ADCP applications

6.2.1 Be sure that your proposed deployment location is free of marine cables and that if man-made electrical fields are present, consider collecting the data in beam coordinates rather than relying on the internal fluxgate magnetometer to rotate the results into east-west (u), north-south (v), and up-down (w) components.

6.2.2 Plan your deployment! Typically we collect data at six-minute intervals. We average 90, 1-second pings and then have the ADCP shutdown for 4.5 minutes to save on battery life. The duration, vertical resolution (bin size), and battery life can all be estimated using the PlanADCP software. Maximum depth for the tackle Ecology presently owns is about 50-60 meters, depending on the tidal range. Ecology has 32MB data storage cards installed in both units, but these can be upgraded if necessary. Depending on the likelihood of biofouling (depth, sunlight, time of year) you might have to prepare the four heads of the ADCP with something to protect them. We have used marine bottom paint for this purpose (refer to Section 9.0 concerning safety), but there may be less toxic alternatives. Try to save the ADCP without the paint on it for Skookum-mounted applications that do not (typically) need protection from biofouling because they are of short duration; we do not leave the ADCP permanently mounted on the boat.

6.2.3 Prepare the ADCP as follows:

6.2.3.1 Add a fresh battery pack (Figure. 4). To change the batteries open the back of the ACDP (away from the heads). It is easier to change the battery from the connector end because of its mounting configuration. Don't remove the back until you have identified beam 3 on the casing, and the position of the heads, so that you can put it back together the same way. ADCPs use a face seal because RDI found that the old box seals failed more. Be careful! Remove the bolts on the battery end of the unit; remove the old battery and desiccant pack. Take note on the position of the rubber band and the way it secures the desiccant away from the circuit boards.
In reality you can remove the battery by opening either end the less you need to remove the ADCP from the transducer end the better. The seals on either side are the same however every time an end cap is opened there is potential for negative pressure inside the ADCP which can cause a vacuum effect. This vacuum effect can pull moisture into the ADCP. Additionally if contaminants remain on the o-ring when resealed leaks may

occur and it is never ideal to have the leak source located directly adjacent to the board stack.

6.2.3.2 Be sure to add new desiccant.

6.2.3.3 If you flip beam 3 so that it is to your right when you remove the back, mount the battery so that the white ponytail (and often the degauss sticker) are to your left. Feed the white ponytail through the rubber band on the battery pack so that it is taught (and feeds through from the left).

6.2.3.4 Add the backing plate, washers, and then wing nuts (to hand tight). Attach the desiccant with a rubber band wound around the wing nuts so that it does not get loose and touch the circuit board.

6.2.3.5 Re-grease the o-ring with Dow Corning 111 valve lubricant and sealant (or equivalent) silicone grease. Be sparing and remove all particles of sand or dirt.

6.2.3.6 Add the outside bolts so the nuts face the inside, and the bolt heads project toward the end(s). Put one washer under the head of each bolt and two under the nut.

6.2.3.7 Plan your deployment with PlanADCP (see www.rdinstruments.com for latest details). (We use an average ensemble interval of six minutes (00:06:00.00) and a ping frequency of 00:01.5 time/ping (TP00:01.50))…

6.2.3.8 Calibrate the ADCP with the new battery away from stray magnetic fields (AX command). You'll need a laptop with the software, the cables, and a non-magnetic lazy Susan. Set the time in the ADCP to Pacific Standard Time (PST).

6.2.3.8.1 Lazy Susan operator –

6.2.3.8.1.1 Brush the heads in order 1-2-3-4.
6.2.3.8.1.2 Rotate flat, 360 degrees on primary axis.
6.2.3.8.1.3 Rotate pitch/roll – lift by 10–20 degrees up on side 3 with a non-magnetic tilting block, rotate 360 degrees on primary axis.
6.2.3.8.1.4 Rotate roll/pitch – lift by 10-20 degrees up on adjacent side, 360 degrees on primary axis.
6.2.3.8.1.5 Final rotation – not as critical. Rotate somewhere between (and not as much), 360 degrees on primary axis.

6.2.3.9 Erase the old data, use ErAsE.

6.2.3.10 Remember to start the data collection either in air (after calibration) or on the boat in a safe dry place!

6.2.3.11 A workhorse Sentinel ADCP consumes about 2.2 watts of power while awake and responding to commands, which is about five days on a single battery pack. When the

unit is asleep, it consumes less than one mW. Typically a fully charged ADCP can be deployed for about three months, but this depends on many factors and is best determined with the manufacturer's software (ADCPlan).

6.2.3.12 The final configuration of the gear is highly dependent on the deployment site and the experience of the operator. A typical assembly ready for installation is shown in Figure 5.

Figure 5. ADCP in mount ready for deployment with A-frame on R/V Skookum.

6.24 Testing and Preparation of Acoustic Release

6.24.1 The acoustic release should be clean and tested prior to use. To test the release, add a new (or slightly used) battery pack and evaluate its function by triggering it in air with the deck box. This can be done during preparations at the O.C.

6.25 Recovery Procedure

6.25.1 Recovery of Instrument

6.25.1.1 The preferred method to retrieve the ADCP gear is to trip the acoustic release by ensonifying the water column using the Benthos deck box (Fig. 6). The deck box is charged by plugging into 110 V AC power on the Skookum and discharged by the operator. A hydrophone is included in the kit, and this must be plugged into the deck box by a knowledgeable operator. The hydrophone should be lowered into the water typically as deep as possible to get below the pycnocline. Sound can easily be diffracted by density differences in the water column. In an extreme

Figure 6. Benthos-type deck box plugged into 110 VAC with hydrophone attached.

case (heavily stratified) you can be right over the release and not be able to get sound to it. Be aware that each release has a specific frequency (e.g., 10 kHz) and a release code (e.g., 'A') that have to be selected by the operator in order for the release to work. Try the procedure several times and keep watch for the float (it may come up under the boat, so don't have the propeller in gear). If you are successful, use a boat hook to retrieve the float and line. Lead the line up and over a block in the A-frame and to the anchor windlass specially designed to retrieve this tackle (Fig. 7).

Figure 7. Power windlass secured by capstan on Skookum to raise ADCP (missing actual photo).

6.25.1.2 If the acoustic release does not work, the grapple hook should be tried if conditions that day allow for it. The original figure in the log gives the orientation of the snag-line, which is important for the boat's skipper to consider in the search.

6.25.1.3 In the event this is unsuccessful, the next trip should be timed shortly after the time-release is set to go off. With luck the buoy will be waiting for you at the surface. If not, the grapple hook and possibly SCUBA or even submarine (ROV) assistance may be required.

6.25.2 Recovery of Data

6.25.2.1 Data can either be download via the WinSC software with the powered data cable attached to the ADCP (memory is non-volatile, so this works with a dead ADCP battery) or by removing the ADCP transducer-side head (everything stated previously about re-packing o-rings applies here) and extracting the PCMIA data cards – these can be inserted in most laptops for a quick download. Serial downloads via the data cable can take an hour or more; the advantage is that you do not have to open the case to the ADCP.

6.26 Storage Procedure

6.26.1 All gear should be hosed down with fresh water, decontaminated, and dried prior to storage. Biofouling may need to be scrubbed or even scraped off, but care should be taken with the ADCP itself, especially the heads (i.e., know what you are doing).

6.26.2 All gear has a place (and it may be subject to change). When in doubt, ask the O.C. Manager (presently Tim Zornes). Line is stored in the ropes locker area; the mounts are okay outside but _not_ in the direct sunlight. The ADCPs, releases, and pingers have a shelf in the marine locker.

6.3 Skookum Operations

Before launching the Skookum, feed a line underneath the boat to help secure the ADCP mounting beam so that it will not vibrate during operation. Guy lines fore and aft may also be used to secure the mounting pole. The ADCP secured to it with two large radiator hose clamps such that beam 3 is forward. Transiting between transects is often done at high speed and the mounting pole is typically secured in a horizontal position by releasing the guys and rotating the pole at the pivot. At the beginning of a new transect, the ADCP mount is positioned vertically and secured.

6.3.1 Computer connections. Connect the I/O cable to the laptop and ADCP. Also connect the DGPS to COM2 and the fathometer to COM3 if that is desired. Extra COM ports may be added to a laptop using PCMCIA cards, as necessary.

6.3.2 The DGPS option should use the Global Geoid Altitude (GGA to “on”) and the NMEA serial communication should be set to 4800, 8, N, 1.

Turn on power by plugging in power cables to ship’s AC power for the laptop and ADCP, in that order. Check to see that the laptop is not running on battery to prevent loss of data during transects.

Data acquisition – before starting each transect, decide on a consistent convention for naming the shorelines “right” and “left.” The recommended convention allows a flooding tide to be positive and an ebbing tide to be negative. Be sure that bottom-tracking is engaged in the WinRiver software. The ship speed will typically need to be less than five knots, or the point at which too many dropouts on the computer screen are observed. One person should watch the ADCP to make sure it stays in position and does not snag seaweed or hit other debris. Be sure to fill out a log sheet for each transect. A minimum velocity of 0.05 m/s should be detectable. In strong currents, the boat operator will have to maintain a ferrying angle such that the boat moves along the desired

transect. If the combined speed of the boat and current exceeds 5 knots, data collection may not be possible.

Command details are in Teledyne RD Instruments documentation:
F4 starts pinging.
F5 begins the transect.
F5 also ends the transect and stores the data onto the hard disk.
F4 stops pinging, which is not necessary if starting another transect immediately.

Configuration files for different depths can be stored as .wrc files, which saves set-up time. Consult the WinRiver documentation for more details.

6.4 Ferry Operations

6.4.1 If not already installed by the shipyard, the Zelux-barnd polycarbonate window is affixed to the outer lower opening of the sea chest (from below).

6.42The ADCP is lowered into the sea chest (from above), aligned with beam #3 towards the bow (#1 end) of the vessel, and bolted in to place. The bronze collar should be mated flat against the inner hull of the vessel. The alignment of beam #3 is essential to the rectification of the raw water velocity into a fixed (earth) reference frame during data processing. This alignment should be documented with a digital picture, and then later the 'EA' value set to zero in the VMDas software.

6.5 The wet end of the ADCP data/power cable should be connected, using the factory-supplied connectors, and the cable should be threaded out of the sea chest thru a stuffing tube.

7 The sea chest should be closed and sealed (with the lid), and the lower chamber filled with fresh water using the fill and vent tubes.

8 The data/power cable should be threaded out to the junction box, using appropriate penetrations for any bulkheads along the cable route. This must be performed by a licensed marine electrician (shipyard employee).

9 The cable is terminated to a DC power supply and a serial-to-Ethernet convertor in the junction box.

10 ADCP communication is tested and confirmed using a laptop with VMDas software, connected via the network onboard the vessel (and emulating a serial port as an IP address).

11 NMEA navigational data are output from GPS system in the pilot house and made available on the same network via serial-to-Ethernet convertor. Communication is tested and confirmed using a laptop with VMDas software.

12 Data acquisition computer is installed onboard and connected to network, using fixed IP address assigned by network administrator. Communication with ADCP and receipt of NMEA data are confirmed. Networked power supply is used for computer.

13 Data acquisition computer is configured for daily acquisition (via auto run feature in VMDas software) of ADCP and NMEA data and nightly ftp offload (via winscp script) to server onshore.

7.0 Records Management

7.1 For each site where fixed-mount ADCPs are installed, the standardized field log sheets provided in Appendix A should be used to record station information such as field conditions, location, serial numbers of equipment, and other relevant information are considered necessary. For Skookum-mounted applications likewise use the field log sheets provided in Appendix B. Upon returning to the Operations Center (OC) gear must be cleaned and dried for long-term storage. Log sheets are entered into the database by field staff after completion of field excursion for either fixed-mount or Skookum-mount applications.

7.2 For fixed-point ADCP at: Y:\SEABIRD\ADCP\BottomMount

7.3 For Skookum-mounted ADCP at: Y:\SEABIRD\ADCP\SurfaceMount

7.4 For ferry data results are managed by UW-APL and are available to Ecology via OpeNDAP at
'http://107.170.217.21:8080/thredds/dodsC/Salish_L1_STA/Salish_L1_STA.ncml'
OPeNDAP, an acronym for "Open-source Project for a Network Data Access Protocol", is a data transport architecture and protocol widely used by earth scientists.

7.5.1 Digital pictures and written notes are taken to accompanying each step in the procedures list.

7.5.2 Data files are time-stamped when recorded and organized by day.

7.5.3 Data files are transmitted to redundant (two) ftp servers, and local data copies are maintained onboard the vessel. Raw data are physically removed (hard drive exchange) from the vessel every 3 months.

7.5.4 The ADCP and VMDas configuration files must be saved and archived after Quality Assurance is met and the final configurations are established.

8.0 Quality Control and Quality Assurance Section

8.1 Field Quality Control

8.1.1 The fourth transducer head on the ADCP provides a built-in error estimate of the errors in measuring the three dimensions of water velocity: u, v, and w. Because the geometry of the transducer heads is fixed (e.g., 20 degree rotation out of the horizontal plane) the uncertainty estimates of the upwelling/downwelling term (w), will be larger than for the horizontal components (u (east-west) and v (north-south). Depending on the study design, multiple passes along a survey may be advisable for vessel-mounted applications. It is often better to make several passes along a single transect than a single pass along multiple transects.

8.2 Data Entry and Log Sheet Quality Control

8.2.1 Each log sheet that is entered into the database by one of the field staff is rechecked for errors by other staff after entry. Date and technician who entered the data are written on the log sheet for reference after entry. Log sheets are currently stored with the ADCP coordinator at their desk.

9.0 Safety

9.1 All field staff must understand and comply with the Environmental Assessment Program (EAP) Safety Manual (2006) with extra emphasis on fall protection, working over water, chemical safety, and chapter 3 of the EAP safety manual "Boating." Proper use of protective barriers (e.g. Nitrile gloves, leather gloves, etc.) is mandatory for field staff.

9.2 Knowledge of MSDS chemical information, storage, disposal, and safety precautions relating to the chemicals (MSDS Trilux White = http://www.yachtpaint.com/msds_pdf/YBA068_GBR_ENG.pdf) is mandatory. Refer to EAP HQ Safety Manual.

10.0 References

10.1 Environmental Assessment Program, 2006. Environmental Assessment Program Safety Manual. March 2006. Washington State Department of Ecology. Olympia, WA.

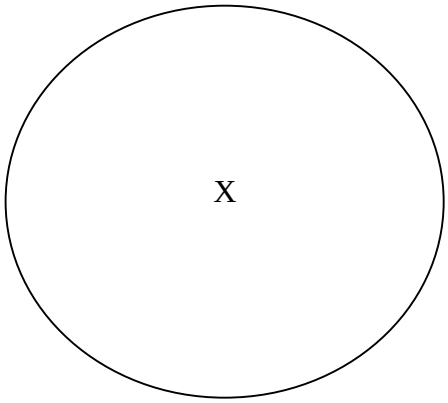
10.2 WorkHorse Sentinel ADCP User's Guide, P/N 957-6163-00 (January 2001), RD Instruments Acoustic Doppler Solutions (Appendix F).

Appendix A – Fixed-mount ADCP field log:
LOG SHEET FOR ADCP BOTTOM DEPLOYMENT

Date: _____ Time: _____ PST (use Pacific Standard Time)
Cruise Name: _____
Location: _____ Boat Driver: _____
Boat Name: _____
ADCP Latitude: _____ Crew: _____
_____
ADCP Longitude: _____

Tag anchor Latitude: _____ Depth: _____

Tag anchor Longitude: _____
Datum (e.g., NAD83) _____
Indicate direction of tag line from ADCP (at X): N

W  E

S

Weather: **Wind Speed _____** (magnetic)
Wind Direction _____ (magnetic)
The direction the wind is coming from, not where it is going

START

Time: _____

Distance from Shore (meters): _____

Acoustic Release (model 875A)

Serial number: _____
Frequency (Hz): _____
Release code: _____ **Pinger? Yes/No** **Snag-line? Yes/No**
Timed release? Yes/No

Appendix B – Skookum-mounted ADCP field log:
LOG SHEET FOR ADCP DATA COLLECTION

Date: _____
Cruise Name: _____
Transect Number: _____ Boat Driver: _____
Boat Name: _____
Transect Name: _____ Crew: _____
_____
Filename: _____

Configuration File Name: _____

Weather: **Wind Speed** _____ (magnetic)
Wind Direction _____ (magnetic)
The direction the wind is coming from, not where it is going

START

Time: _____ PST(/PDT)?

Distance from Shore (meters): _____

Select Bank: **Left / Right**

Transect Direction (heading)**:** _____ (magnetic)

Latitude: _____

Longitude: _____

END

Time: _____ PST(/PDT)?

Distance from Shore (meters): _____

Select Bank: **Left / Right**

Latitude: _____

Longitude: _____

NOTES:

Appendix C
FIELD WORK PLAN & CONTACT PERSON FORM (page 1 of 2)

Field leader complete needed information on both pages. File the electronic copy and attachments in the appropriate folder. Field leader must add a *Float Plan* if Ecology boats are to be used. Field Leader must add information about non-Ecology boats if they are to be used.

Field Leader Name

Field Staff Name(s)

Use the tab key to move through the fields.

Vehicle Info (make, model, color, license)

Vehicle Phone Number

Non-Ecology Boat Name & Phone Number

Non-Ecology Boat Operator's Name & Phone Number

Date/Time of Departure

Estimated Date/Time of Return

Sampling "Run" or station list description (attach separate sheet or map if preferred):

Run/Station/Facility/Site and Location

Driving Directions (attach separate sheet or map if preferred):

Lodging Plan:
Date, Hotel/Motel, and Phone Number

FIELD WORK PLAN & CONTACT PERSON FORM (page 2 of 2)

Complete this page if field work goes after regular working hours or involves overnights stays.

Contact Person & phone to notify to close Field Work Plan

(Contact Person can be anyone able and willing to perform search operations).

Date/time to begin search operations if field crew hasn't checked in

Search Operations

The following steps should be taken by the contact person if the field crew doesn't check in by the time given above to close the Field Work Plan.

1. Call the vehicle or boat's phone (can try VHF ch.16 if boat).
2. Call the field leader. Office Home
3. Call other field staff. Office Home
4. Call the scheduled hotel(s).
5. Call other places or persons who may have information on whereabouts of field crew (e.g. friends, family, co-workers).
6. Check Ecology or other parking lots for the vehicle.
7. Call the Unit Supervisor or designated backup to inform them of the situation and reach a decision whether to contact the Washington State Patrol and/or pursue other search activities.

Unit Supervisor: Name (Select) Home

Designated Backup: Name Office # Home

If warranted, call the *Washington State Patrol Emergency Dispatch (800-283-7808)* and request a road check of the route the vehicle would take while doing field work. Give WSP a vehicle description (make, model, year, color, license plate number). Ask WSP dispatch whether you should contact the local County Sheriff's office.

8. In case of extended search operations or emergencies, the contact person should call the following persons designated by the field staff (e.g. family members, friends):

Name Phone

Name Phone

Name Phone

Name Phone

Appendix D

Skookum-mounted ADCP Checklist

Office & Electronics

- O Laptop Computer (w/ power cord)
- O Data stick for backing-up data
- O Metal Clipboard
- O Float Plan x3 (Section Secretary, Contact, Field)
- O Sample Logs
- O Tide Table
- O Cell Phone (w/ charger)
- O Digital Camera
- O MSDS

OC Field Supplies

- O Data cable and power cord for 110-volt ship power (or battery)
- O Life Jackets
- O Buckets
- O Mount for ADCP to Skookum (w/lanyard)
- O Boat hook
- O ADCP Rubbermaid Action Packer, Large
- O Tool Box (content details listed below)
- O Cable to interface with DGPS (if desired)

From Wet Lab

- O *Plastic Bags
- O *Label, Electrical and Duct Tape
- O *Sharpies, Pencils and Pens
- O *Connectors
- O *Bottle Brushes & Paper Clip (straightened)
- O *Scissors
- O *Dummy plugs for ADCP
- O *Nitrile Gloves, Med and Large
- O *Extra Plastic Beaker
- O *Kimwipes

Items packed morning of departure

Contents of Bins
Large ADCP Action Packer
(some items duplicative of toolbox)

- Hose Clamps and/or large nylon ties
- Electrical Tape
- Duct Tape
- Zip-Ties, various sizes
- Spare Parts
- Gloves, Nitrile
- Sandwich Box with Allen Wrench
- Kimwipes
- Misc Hardware (screws, nuts, washers, insulators, Teflon tape)
- Plastic Beaker
- Brushes
- Teflon and Wooden Blocks
- Sponges

Toolbox

Screwdrivers
- Large flathead
- Small flathead
- Large Philips
- Stubby Philips

Pliers
- Large diagonal cutters (for large zip-ties)
- Small diagonal cutters (for small zip-ties)
- Needle nose
- Locking

Wrenches
- Adjustable
- Ratchet w/ drivers (various)
- Combo wrenches (various)
- Allen wrenches
- Nut drivers (various, 7 mm for heavy duty hose clamps)
- Hammer
- Electrical tape
- Knife
- Extra ADCP plugs
- Spare nuts, bolts, and ties

Appendix E

Bottom-mount Checklist

Office & Electronics

- O Laptop Computer (w/ power cord)
- O Data stick for backing-up data
- O Metal Clipboard
- O Float Plan x3 (Section Secretary, Contact, Field)
- O Sample Logs
- O Tide Table
- O Cell Phone (w/ charger)
- O Digital Camera
- O MSDS

OC Field Supplies

- O Data cable and power cord for 110-volt ship power (or battery)
- O Life Jackets
- O Power winch with footswitch
- O Buckets
- O Mount with ADCP (and new batteries)
- O Acoustic release (batteries), deck unit and hydrophone
- O Pinger (batteries)
- O Chain, tackle, anchor ball for line canister
- O Viny float, and line
- O Special line that allows release of float from either acoustic or time signal
- O Hefty bag to seal line cylinder
- O Buoyant (floating) yellow snag-line (50 m, > ½-inch, 5000# test)
- O Hose clamps (or nylon ties), and spares
- O Boat hook
- O ADCP Rubbermaid Action Packer, Large
- O Tool Box (content details listed below)
- O Cable to interface with DGPS

From Wet Lab

- O *Plastic Bags
- O *Label, Electrical and Duct Tape
- O *Sharpies, Pencils and Pens
- O *Connectors
- O *Bottle Brushes & Paper Clip (straightened)
- O *Scissors
- O *Dummy plugs for ADCP
- O *Nitrile Gloves, Med and Large
- O *Extra Plastic Beaker
- O *Kimwipes
- O Deck unit and hydrophone (for recovery)

Items packed morning of departure

Contents of Bins

Large ADCP Action Packer

- Hose Clamps and/or large nylon ties
- Electrical Tape
- Duct Tape
- Zip-Ties, various sizes
- Spare Parts
- Gloves, Nitrile
- Sandwich Box with Allen Wrench
- Kimwipes
- Misc Hardware (screws, nuts, washers, insulators, Teflon tape)
- Plastic Beaker
- Brushes
- Teflon and Wooden Blocks

Toolbox

Screwdrivers

- Large flathead
- Small flathead
- Large Philips
- Stubby Philips

Pliers

- Large diagonal cutters (for large zip-ties)
- Small diagonal cutters (for small zip-ties)
- Needle nose
- Locking

Wrenches

- Adjustable
- Ratchet w/ drivers (various)
- Combo wrenches (various)
- Allen wrenches
- Nut drivers (various, 7 mm for heavy duty hose clamps)
- Hammer
- Electrical tape
- Knife
- Extra ADCP plugs
- Spare nuts, bolts, and ties

Appendix F

WorkHorse Sentinel ADCP User's Guide

P/N 957-6163-00 (January 2001)

RD Instruments

Acoustic Doppler Solutions

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WorkHorse Sentinel User's Guide

1 Introduction

Thank you for purchasing the RD Instruments (RDI) WorkHorse. This guide is designed to help first time WorkHorse users to set up, test, and deploy their ADCP.

This guide is designed for use *with* the other WorkHorse Technical Manual books. Where needed, there are references to detailed information and figures contained in the WorkHorse Technical Manual.

WorkHorse Sentinel deployments are most often Self-Contained but can be

Real-Time. Typically, deployments are considered to be Self-Contained when the ADCP is remotely deployed and powered using internal batteries. In this configuration, no external connections to the ADCP are made during the deployment. However, the ADCP can be connected to external power. This power can be provide either by an external battery case or from shore. This type of deployment is still considered Self-Contained, but this quick reference guide may not consider all of the possibilities of this application. Real-Time use refers to the fact you are viewing the data as the ADCP collects it via a personal computer. This data are also stored on the computer to allow for data playback and processing at a later time.

NOTE. When you receive your WorkHorse, look for a set up card that shows all of the pieces you should have in your box. If anything is missing or damaged, contact RDI immediately.

2 WorkHorse Sentinel ADCP Applications

The WorkHorse Sentinel ADCP is designed so that it can be used as a fully self-contained system. This means that it contains its own battery for power and internal recorder for the storage of all data that you have set it up to collect. Using the internal battery and recorder, the WorkHorse Sentinel can be used for several-month autonomous current profile deployments from temporary or permanent mountings in the ocean, near-shore, harbors, and lakes.

WinSC is the software package for self-contained ADCP setup, data collection, and data review. For detailed information on how to use *WinSC*, see the *WinSC* User's Guide. *Plan* (part of *WinSC*) lets you enter known or "best-guess" values for the various ADCP profiling parameters and shows predictions of expected results. For detailed information on how to use *Plan*, see the *WinSC* User's Guide.

Table 1: WorkHorse Self-Contained Application Guide

Application	**Blue Water**	**Costal and Continental Shelf**
	Sentinel using WinSC	**Sentinel using WinSC**
	□ Oceanography	□ Environmental monitoring
	□ Energy transport	□ Costal engineering
	□ Environmental monitoring	□ Enabling safe movement
	□ Engineering stress determination	□ Measuring Power plant discharge
	□ Circulation/model studies	□ Protecting coastal land forms
	□ Boundary layer studies	□ Detecting sewer outfall
	□ Monitoring sensitive environments	
Autonomous deployment	□ Planning new ports	
Lowered	**Sentinel using WinSC**	
	□ Deep water oceanography	

The WorkHorse Sentinel ADCP is also able to be used in real time applications that either takes advantage of the internal battery power, or external battery power, and can be used to collect data internally as well as externally. When considering real time applications, RDI offers you choices in software packages that are intended to directly meet your needs. *VmDas* is the most often used software package for ADCP setup, real-time data collection,

and data review. For detailed information on how to use *VmDas*, see the *VmDas* User's Guide.

Table 2: WorkHorse Real-Time Application Guide

Application	**Blue Water**
Real-Time deployment	**Costal and Continental Shelf** **Sentinel using VmDas** □ Oil production platforms □ Current mapping **Sentinel using VmDas** □ Oceanography □ Boundary layer studies □ Fisheries
Boat Mount (portable)	**Sentinel using VmDas** □ Plankton biomass
Towed	**Sentinel using VmDas** □ Towed fish positioning □ Boundary layer studies □ Circulation/model studies
Offshore oil and gas	**Sentinel using VmDas** □ Seismic prospecting □ Exploration drilling □ Field development □ Production

Sentinel using VmDas	**Sentinel using VmDas**
□ Port and harbor monitoring	□ Current mapping
□ Water quality studies	□ Plume tracking
□ Environmental surveys	□ Planning new ports
□ Current mapping	□ Towed fish positioning
□ Towed fish positioning	□ Water quality studies

Table 3: WorkHorse Special Applications

Sentinel using WinRiver	**Sentinel using Waves**
□ River, stream and channel discharge	□ Coastal protection and engineering
□ Suspended sediment load estimation	□ Port design and operation
□ Plume tracking	□ Environmental monitoring
□ Bridge scouring	□ Shipping safety
□ Simultaneous bathymetry discharge, flow structure	

NOTE. For information on how to use a Sentinel in river discharge measurements, see the *WinRiver* User's Guide. For information on how to use a Sentinel to monitor waves, see the *Waves* User's Guide.

3 System Overview

The Sentinel ADCP system consists of an ADCP, cables, battery pack, flash memory card, and software. Both battery capacity and memory can be increased with upgrades for longer deployments. The Sentinel can also be used for direct-reading current profile operation. They only require the addition of a Windows® compatible computer to configure the ADCP and replay collected data.

3.1 Sentinel ADCP Overview

The transducer assembly contains the transducer ceramics and electronics. Standard acoustic frequencies are 300, 600, and 1200kHz. See the outline drawings in the WorkHorse Installation Guide for dimensions and weights.

I/O Cable Connector – Input/Output (I/O) cable connects the WorkHorse ADCP to the computer.

Beam-3 Mark – The Beam-3 mark shows the location of Beam-3 (Forward).

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

Housing – The standard WorkHorse housing allows deployment depths to 200 meters.
Thermistor – The Thermistor measures the water temperature.
Pressure Sensor – The Optional pressure sensor measures water pressure (depth).
Transducer Head – The WorkHorse electronics and transducer ceramics are mounted to the transducer head. The numbers embossed on the edge of the transducer indicates the beam number. When assembling the unit, match the transducer beam number with the Beam 3 mark on the end-cap.
End-Cap – The end-cap holds the I/O cable connector. When assembling the unit, match the Beam 3 mark on the end-cap with beam 3 number on the transducer.
Internal Battery Pack – The internal battery pack has 400 watt-hours (Wh) of usable energy at 0 C. When fresh, the voltage is +42 VDC. When depleted, the voltage drops to 30 VDC or less.
Flash Memory Card – Flash memory cards are available in 16, 20, 40, 85 and 220-MB cards. The standard configuration is one 16MB card.

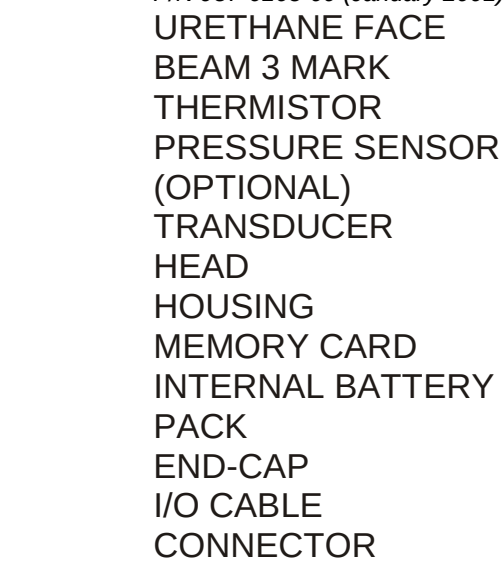

Figure 1. Sentinel ADCP Overview

3.2 I/O Cable Overview

Always remove the retaining strap on the end-cap underwater-connect cable and dummy plug when disconnecting them. **Failure to do so will break the retainer strap.**
Do not apply any upward force on the end-cap connector as the I/O cable is being disconnected. **Stressing the end-cap connector may cause the ADCP to flood.** Read the Maintenance guide for details on disconnecting the I/O cable.

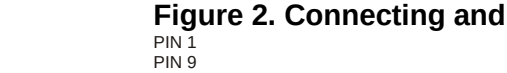

Figure 2. Connecting and Disconnecting the I/O Cable

32985
P2
12564
37
POWER +
POWER -
COMMUNICATION RETURN
RS-232 IN / RS-422 OUT A
RS-232 OUT / RS-422 OUT B
RS-422 IN A
RS-422 IN B
J1
P1
BLK
WHT
BLU
BRN
GRN
RED
YEL
P1 J1 P2
7
6
5
4
1
2
3

Figure 3. I/O Cable Overview

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3.3 Battery Pack Overview

WorkHorse Sentinel ADCPs require +20 to 60 VDC to operate. The standard AC Adapter runs on any standard AC power and supplies +24 VDC to run the Workhorse when the batteries are not connected.

If both the battery (either Sentinel internal batteries or the External Battery Pack) and power supply are connected, the Workhorse will select the *highest* voltage source for use. The batteries (when fresh) supply +42 VDC and the power supply output is +24 VDC. The Workhorse will draw all power from the battery if the battery voltage is above +24 VDC (the power supply will have no effect).

NOTE. The +24 VDC AC adapter does not override the battery voltage! Substitute your own power supply with a voltage of +45 to 60 VDC to override the +42 VDC alkaline battery packs.

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

NOTE. 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. It provides an option for extended ADCP deployments.

INTERNAL
I/O CABLE
THREADED

ROD (4)
WING NUT (4)
WASHER (4)
RUBBER BANDS
BATTERY PACK
LOCK WASHER (4)
BATTERY
CABLE
SPACER (4)
DESICCANT
RUBBER BAND
SUPPORT PLATE

Figure 4. Battery Pack Overview

CAUTION. The Workhorse Sentinel battery pack is 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 wing nuts to help hold them in place.

3.4 Flash Memory Card Overview

Flash memory cards are available in 16, 20, 40, 85 and 220-MB cards. The internal recorder holds two cards for a maximum of 440 MB of recording space. The PC Card recorder is located on the Digital Signal Processor (DSP) board inside the Workhorse's electronics. To recover data, the card can be removed and used in a personal computer (PC), or left in the Workhorse, and accessed by using *WinSC* (see the *WinSC* User's Guide).

Figure 5. Memory Card Overview

3.5 Spare Parts

The following parts are included in the spare parts kit.

Table 4: Spare Parts

Description	Part number
O-ring, face	2-260
Desiccant, sealed bag	DES3
Lubricant, silicone, 5.3 oz, Dow-Corning	DC-111
Fuse, 3.0 Amp, 250V	GMA-3A

4 WorkHorse Care

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

4.1 General Handling Guidelines

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

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

 Do not apply any upward force on the end-cap connector as the I/O cable is being disconnected. **Stressing the end-cap**

connector may cause the ADCP to flood. Read the Maintenance guide for details on disconnecting the I/O cable.

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

 Do not store the ADCP in temperatures over 75 degrees C. **The urethane faces may be damaged.** Check the temperature indicator inside the shipping case. It changes color if the temperature limit is exceeded.

 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 by the external I/O cable. **The connector or cable will break.**

4.2 Assembly Guidelines

 Read the Maintenance guide for details on WorkHorse reassembly. Make sure the housing assembly O-rings stay in their groove when you re-assemble the WorkHorse. Tighten the hardware as specified. **Loose, missing, stripped hardware, or damaged O-rings can cause the WorkHorse transducer to flood.**

 Place a light amount of DC-111 lubricant on the end-cap connector pins (rubber portion only). **This will make it easier to connect or remove the I/O cable and dummy plug.**

 Do not connect or disconnect the I/O cable with power applied. An exception to this is the external battery case. The external battery case connector is always “hot” when batteries are installed. When you connect the cable with power applied, you may see a small spark. **The connector pins may become pitted and worn.**

 The WorkHorse I/O cable is *wet* mate-able, not *under water* mate-able.

4.3 Deployment Guidelines

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

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

 Avoid using ferro-magnetic materials in the mounting

fixtures or near the Workhorse. **Ferro-magnetic materials affect the compass.**

5 Setup the WorkHorse Sentinel ADCP

Figure 6 illustrates how to connect the WorkHorse cables and adapters on your workbench. The internal battery plugs into a connector on the top circuit board.

NOTE. When you first receive your WorkHorse, the battery is not installed.

You will need a container of water large enough to submerge the Work-Horse's transducer head into during testing (two to three inches of water is sufficient). Testing the WorkHorse out of water may cause some tests to fail but causes no harm to the WorkHorse.

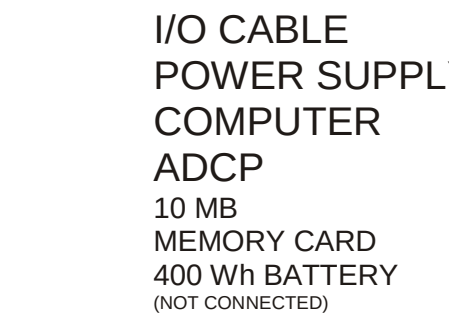

Figure 6. WorkHorse Sentinel Connections

5.1 Serial Communication

The standard communications settings are RS-232, 9600-baud, no parity, 8 data bits and 1 stop bit. Self-contained applications receive no benefit from setting a faster baud rate.

You can set the WorkHorse for baud rates other than 9600 baud. If you make the new baud rates permanent, *WinSC* will search for the correct settings, (and will try COM2 but not COM3 or COM4). If you tell *WinSC* these settings, you will save time required for searching. If you have trouble connecting to the WorkHorse, use *WinSC's* **Auto Detect**, which searches for the WorkHorse's current serial port and baud rate.

RS422. The WorkHorse Sentinel is normally set for RS232, but it can be changed to RS422 by changing a switch setting. The switch is in plain view on the top circuit board, near the cable connectors. Its settings are plainly

marked on the board. If the serial protocol is set for RS422 and your computer expects RS232, you will need an RS232-RS422 adapter between the WorkHorse cable and your computer. This user's guide assumes that you use RS232. There is no reason to use RS422 for Self-Contained operation.

5.2 What if the WorkHorse Does Not Respond

If your WorkHorse does not respond, check the serial port, cables, AC power, and battery connection. If necessary, refer to the Troubleshooting Guide in the WorkHorse technical manual.

NOTE. WorkHorse Sentinels are shipped from the factory without the battery installed in the housing. Be sure to install the battery before

deployment!

6 Software

RDI has utility programs to help you set up, use, test, and trouble-shoot your WorkHorse ADCP. Each program has a help file that you can print, or you can view help while running the program.

Table 5: WorkHorse Software

Program Name	Description
DumbTerm	Windows ADCP communication program. Use this program to "talk" to the ADCP and to run test script files. *DumbTerm* is included on the RDI Tools CD. For detailed information on how to use *DumbTerm*, see the *RDI Tools User's Guide*.
WinADCP	Gives users a visual display of the entire set of data. You can zoom in on a portion of the data for closer analysis and you can export data to text or MatLab files. For detailed information on how to use *WinADCP*, see the *WinADCP User's Guide*.
Documentation CD	The Documentation CD has an Adobe Acrobat® (*.pdf) electronic version of the WorkHorse Technical Manual. Use the Documentation CD to search for information. For detailed information on how to use Adobe Acrobat® and the Documentation CD, see the Read This First guide.

NOTE. See "WorkHorse Sentinel ADCP Applications," page 2 to see what software package to use for collecting data.

6.1 System Requirements

The WorkHorse software requires the following:

- Windows 95®, Windows 98®, or Windows® NT 4.0 with Service Pack 4 installed
- Pentium class PC 233 MHz (350 MHz or higher recommended)
- 32 megabytes of RAM (64 MB RAM recommended)
- 6 MB Free Disk Space (20 MB recommended)
- One Serial Port (two High Speed UART Serial Ports recommended)
- Minimum display resolution of 800 x 600, 256 color (1024 x 768 recommended)

6.2 Software Installation

To install the WorkHorse software, do the following.

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

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

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

d. Follow the browser instructions on your screen

6.3 Utility Software

The following DOS programs (on the RDI Tools CD) have been provided to supplement features not yet implemented into the Windows environment. RDI will incorporate these features in future releases. These programs have

been installed to the directory C:\Program Files\Rd Instruments\Utilities.

Table 6: WorkHorse DOS Utility Software

Program Name	Description
BBLIST	Executable program that can be operated through the Windows environment. This program will display binary data in tabular format as well as convert the data into an ASCII file.
BBBATCH	Automatically converts a named binary data set to a named ASCII data set using an existing format file. Use this program to convert binary files unattended through a DOS batch file.
BBCONV	Executable program that cannot be operated through the Windows environment. Removes user selected data from binary files and stores the information into ASCII comma delimited format. See BCONV.DOC for decoder file format.
BBMERGE	Executable program that cannot be operated through the Windows environment. BBMERGE merges ASCII comma delimited format data described by a decoder (.DEC) file into the raw BroadBand ADCP data file "infilename", resulting in an output ADCP data file called "outfilename". See BCONV.DOC for decoder file format.
BBSUB	Executable program that cannot be operated through the Windows environment. BBSUB starts copying ensembles from 'infilename' to 'outfilename' starting with the user specified “Start” and “End” ensemble number. This is intended to allow users to subsection binary data files.
SS	Executable program that can be operated through the Windows environment. SS allows you to quickly calculate the speed of sound in the water.
SURFACE	Executable program that cannot be operated through the Windows environment. Surface estimates the range from the ADCP to the water surface or bottom from the echo intensity data. This program does not change the original data. It creates a text file with the estimated ranges. Intended for customers to estimate where to cut off their data.
CHECKDAT	Executable program that cannot be operated through the Windows environment. CHECKAT will scan a data file for missing ensembles, ensemble number out of order, bad checksum ensembles and ensembles with bit errors. If the DOS redirect command (> symbol) is used then the output will be placed into a file.
C++ Code Library	The C++ Code library has been provided to help you in the creation of your own programs. These files are provided as is and in general are not supported. Use at your own discretion. The files are located in the directory: C:\Program Files\Rd Instruments\Utilities\C_Code.

6.4 WorkHorse Software Philosophy

Self-contained data collection involves a series of independent steps. Using *WinSC’s* Deployment Wizard will ensure that the ADCP is setup correctly.

- Test your WorkHorse (*WinSC*)
- Plan your deployment (Plan can be run separately or run inside

WinSC)
 Transfer your “plan” into the WorkHorse and start data collection (*WinSC*)
 Transfer the data from the WorkHorse’s PC Card recorder to your computer (*WinSC*)
 Verify data integrity (*WinSC*)
 When you are satisfied that your recorded data are safely backed up, erase the WorkHorse PC Card recorder (*WinSC*)
 Display and process your data (*WinADCP* and *WinSC*)

The WorkHorse software is designed to allow you to set up your Work-Horse to get the best possible data without having to understand and use WorkHorse commands. *Plan* creates *command files*. These files hold the commands that will be sent to the WorkHorse to start the deployment.

6.5 File Naming Conventions

The WorkHorse software gives you a complete record of information that might help you understand your data. To help you associate these files with your data, they use the same deployment name. Be careful not to lose these files!

NOTE. Choose and use Deployment Names carefully: they help you identify and organize all the data and log files associated with each deployment.

Raw Data files produced by *WinSC* have the following filename format:

DeployName000.nnn

Where:

DeployName is a user-entered name for the deployment (up to 128 characters),
000 is the deployment number (changes with each stop/restart),
nnn is the recorder card number, which is incremented when the recorder card is full (.000 = card one, .001 = card two)

The file extensions have the following meaning:

DeployName.WHP WorkHorse command file created by *Plan*.
DeployName.SCL Deployment log file created by *WinSC*. This file contains all of the commands sent to the WorkHorse (from *.WHP) and the WorkHorse’s system information before deployment.
DeployName.DPL Binary deployment status file. This file keeps track of which steps were completed when using the deployment wizard.

7 Batteries and Power

All WorkHorse tests and operations work equally well using internal battery packs, external battery packs, or the AC power adapter.

7.1 AC Adapter

The AC Adapter runs on any standard AC power and supplies 24 VDC to run the WorkHorse when the batteries are not connected. Substitute your own power supply with a voltage of 45 to 60 VDC to override the 42 VDC alkaline battery packs.

NOTE. The 24 VDC AC adapter does not override the battery voltage!

NOTE. If you collect data using the AC adapter, the profiling range is reduced compared with standard battery voltage.

NOTE. Transmitted power increases or decreases depending on the input voltage. A fresh battery provides +42 VDC. Batteries spend most of their life at a nominal voltage of +33 VDC.
The transmitted power is decreased 1 DB if the input voltage drops from 42 VDC to 33 VDC. For a 300kHz WorkHorse ADCP, each DB will result in a decrease in range of one default depth cell.

7.2 Alkaline Battery Pack Capacity

RDI specifies its battery packs to have 400 watt-hours (Wh) of usable energy at 0°C.

7.3 External Battery Pack

The External Battery Pack holds two 400 watt-hours (Wh) batteries. To avoid affecting the compass, place the external battery case at least 30-cm away from the Sentinel WorkHorse.

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Figure 7. External Battery Pack Connection

7.4 Reusing Alkaline Batteries

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

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

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

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

 Battery packs differ from one to another.

 If your deployment is important, weigh the cost of a new battery pack against the risk of lost data.

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7.5 Bench-Top Battery Power Requirements

While the WorkHorse is awake and responding to commands, it consumes approximately 2.2 watts. A single internal battery pack supplies this power level for about five days. When the WorkHorse is asleep, it consumes less than one mw. A standard battery pack supplies sleep power for years. At every opportunity, the WorkHorse will “sleep” to conserve power while deployed.

7.6 Operation Modes

The WorkHorse 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 to resume pinging.

In the Command Mode

Whenever you wake up your WorkHorse, power dissipation increases from less than one mw to around 2.2 w. If you leave the WorkHorse in command mode without sending a command for more than five minutes, the Work-Horse automatically goes to sleep. This protects you from inadvertently depleting batteries.

In the Ping Mode

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

8 Testing Your WorkHorse

Use the following steps to test the ADCP.

a. Connect and power up the ADCP as shown in Figure 6, page 11.

b. Start *WinSC* (for help on using *WinSC*, see the *WinSC* User's Guide)

c. At the **Welcome** screen, click **Test an ADCP**. Click **OK**. This will run the pre-deployment tests Deploy?, System?, TS?, PS0, PA, PC2, RS, and PC1. The results of the tests will be printed to the screen and saved to the log file (*.scl).

Table 7, page 19 lists the tests *WinSC* runs, gives you guidelines for running the tests, and tells you what the results mean.

Table 7: WorkHorse ADCP Tests

Test	Guidelines	Results
Deploy?	This will show a list of the deployment commands and their current setting.	Verify the command settings.
System?	This will show a list of the system commands and their current setting.	Verify the command settings.
TS?	This will show the current setting of the real time clock.	Verify the clock setting.
PS0	Displays system parameters.	Verify the information is consistent with what you know about the setup of your system.
PA	Extensive pre-deployment test that tests the signal path and all major signal processing subsystems. This test may not pass unless the WorkHorse transducer face is immersed water.	All tests must pass.
PC2	Continuously updates sensor display.	Rotate and tilt WorkHorse and watch the readings on the display change. Satisfy yourself that the

readings make sense.
RS This will show the amount of used and free recorder space in megabytes. Verify the recorder space is sufficient for the deployment.
PC1 Beam continuity test. Follow instructions to rub each beam in turn to generate a noise signal the WorkHorse uses to verify the transducer beam is connected and operational.
All beams must pass.

9 Compass Calibration

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

- We recommend against calibrating the WorkHorse while on a ship. The ship's motion and magnetic fields from the hull and engine will likely prevent successful calibration.
- If you think your mounting fixture or frame has some magnetic field or magnetic permeability, calibrate the WorkHorse inside the fixture. Depending on the strength and complexity of the fixture's field, the calibration procedure may be able to correct it.

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

9.1 Preparing for Calibration

a. Place the WorkHorse on a piece of strong cardboard on top of a smooth wooden (non-magnetic) table. If a wooden table is not available, place the WorkHorse on the floor as far away from metal objects as possible. Use the cardboard to rotate the WorkHorse during calibration—this way you will not scratch the WorkHorse.
b. Connect the WorkHorse as shown in "Setup the WorkHorse Sentinel ADCP," page 11.
c. Start *DumbTerm*. See the RDI Tools User's Guide for assistance on using *DumbTerm*.

9.2 Compass Calibration Verification

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

NOTE. Verify the compass if you have just replaced the battery, memory module, or any ferrous metals is relocated inside or around the WorkHorse housing.

Start the test with the AX-command and follow the instructions. **Place the ADCP in the same orientation as it will be deployed.** The WorkHorse

can be vertical (it can rest on its end cap), or it can be tilted (it could rest on a transducer face). Whatever its tilt, the tilt must remain constant as you rotate the WorkHorse. When prompted, rotate the WorkHorse smoothly and slowly. Pay particular attention to the Overall Error. For example;

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

If the overall error is less than 5°, the compass does not require alignment. You can align the compass to reduce the overall error even more (if desired).

NOTE. *WinSC* does the compass verification as part of the Deployment Wizard (see "Verify the Compass," page 30).

9.3 Compass Calibration Procedure

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

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

a. Start *DumbTerm*.
b. Start the test with the AF-command and choose the calibration type.
c. Place the ADCP in the same orientation as it will be deployed.
d. When prompted, rotate the WorkHorse slowly 360 degrees.

e. The second rotation requires the WorkHorse to be tilted on an adjacent beam. Follow the on-screen instructions to orient the unit correctly. Tilt an upward-looking WorkHorse with a block under one side of the end cap. A 35-mm block gives you an 11º tilt. When prompted, rotate the

WorkHorse slowly 360 degrees.
f. If the calibration procedure is successful, it records the new calibration matrix to nonvolatile memory. The WorkHorse will not change its matrix unless the calibration is properly carried out.
g. If the calibration procedure is not successful, return your WorkHorse to the original factory calibration, by using the AR-command. Try using the AR-command if you have trouble calibrating your compass. In some circumstances, a defective compass calibration matrix can prevent proper calibration.

Figure 8. Compass Alignment

10 Internal Pressure Sensor

If you have the optional pressure sensor installed in your ADCP, use the AZ-command to zero out the pressure sensor at the deployment site.
a. Connect and apply power to the system as described in "Setup the WorkHorse Sentinel ADCP," page 11.
b. Start *DumbTerm* and wakeup the ADCP (press the **END** key).
c. Type **AZ** and press the **Return** key.
d. Exit *DumbTerm*.

10.1 Pressure Sensor Maintenance

In order to read the water pressure (depth), water must be able to flow through the copper screw on the pressure sensor. Antifouling paint will block the sensor's port (a small hole that is drilled through the copper screw). You should tape off the screw during anti-fouling paint application. This means that the sensor port is not fully protected from bio fouling. The sensor port is surrounded by the antifouling paint, but bio fouling may build up on the screw, and eventually clog the sensor port. However, most organisms do not seem to find the small amount of unpainted surface attractive.
If it is logistically possible to periodically inspect/clean the pressure sensor screw, it is highly recommended. This tradeoff situation must be analyzed for individual deployments. Unfortunately, the location of the deployment site usually dictates action in this regard.

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

CAUTION.
The pressure sensor is filled with silicone oil. Never poke a needle or other object through the copper screw while the screw is installed over the pressure sensor. You will perforate the sensor, causing it to fail.
Do not remove the cover disc or attempt to clean the surface of the pressure sensor. The diaphragm is very thin and easy to damage.
Do not remove the pressure sensor. It is not field replaceable.

11 Deployment Guide

Use the following steps and the Quick Reference card to setup the Work-Horse for a Self-Contained deployment.

11.1 Deployment Checklist

- Test the ADCP using *WinSC*
- Seal the ADCP for deployment
- Install new o-rings; use silicone lubricant
- Use fresh desiccant (2 bags) inside ADCP
- Install and connect the battery
- Check Recorder PC card is installed
- Visually inspect the ADCP
- Check the transducer head condition
- Check the zinc anode condition (High Pressure Housing only)
- Check the housing paint condition (High Pressure Housing only)
- All mounting hardware installed
- Transducer faces clean and free from defects
- Verify the compass alignment using *WinSC*; if necessary, re-calibrate
- Check recorder status using *WinSC*
- Are biofouling precautions needed?
- Verify battery and recorder space requirements
- Zero pressure sensor (optional) at deployment site with AZ-command
- Install the dummy plug; use silicone lubricant

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TRANSDUCER HEAD
CHECK O-RINGS
AND MOUNTING
HARDWARE ARE
INSTALLED
ELECTRONICS AND
BATTERY PACKS
CHECK MEMORY CARD
AND BATTERIES ARE
INSTALLED
END-CAP
CHECK O-RINGS AND
MOUNTING HARDWARE
ARE INSTALLED
I/O CABLE CONNECTOR
INSTALL DUMMY PLUG
HOUSING
CHECK FOR
CRACKS
URETHANE TRANSDUCER FACES
REMOVE BARNACLES AND
CHECK FOR CRACKS
VISUALLY INSPECT THE ADCP

Figure 9. Visual Inspection before Deployment

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11.2 Prepare the ADCP for Deployment

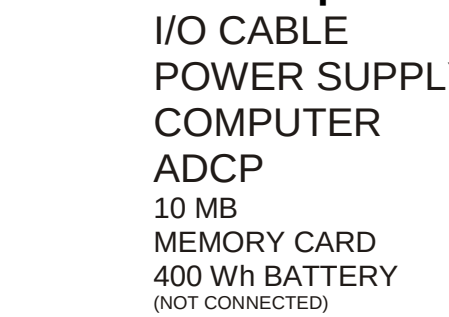

Figure 10. Prepare the ADCP

Things to remember while preparing the ADCP.

 Use the Deployment Checklist to verify that the ADCP is ready for the deployment.

 Test the ADCP using *WinSC*. Some tests will fail if the ADCP is not placed in water while the tests are being run.

 Use the AC power supply while testing the ADCP. Save the batteries for deployments.

 Desiccant lasts a year at specified WorkHorse deployment depths and temperatures. Remember that desiccant rapidly absorbs moisture from normal room air. Replace the desiccant whenever the WorkHorse housing or end-cap is removed.

 Verify the compass calibration.

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11.3 Use the Deployment Wizard

Figure 11. Using the Deployment Wizard

There are five steps the **Deployment Wizard** helps lead you through; Planning, Setting the ADCP's clock, Compass Verification, Pre-Deployment Tests, and sending/verifying the commands to the ADCP. RDI highly recommends using the wizard each time you deploy the ADCP. The deployment wizard will start whenever a new deployment file is created. To use the deployment wizard, do the following.

a. Connect and power up the WorkHorse.

b. Start *WinSC*.

c. Start the Deployment Wizard by doing *one* of the following.

 At the **Welcome** screen, click **Configure an ADCP for a New Deployment**. Click **OK**.

 Click **File**, **New Deployment** (the deployment wizard will start automatically).

 If you are working on an open deployment file (*.dpl), on the **Functions** menu, click **Deployment Wizard**.

NOTE. Choose and use Deployment Names carefully: they help you identify and organize all the data and log files associated with each deployment.

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11.3.1 Plan the Deployment

The first step in the Deployment Wizard is planning. When you click **Next**, the program *Plan* will start. For more information on *Plan*, see the *WinSC* User's Guide. If you want to skip this step, check the **Skip** box, or click **Next** to begin using *Plan*.

*.WHP
COMMAND FILE
set deployment parameters
Choices - Consequences
Range
Resolution
Battery Usage
Memory Requirements
Use the Deployment Wizard to

Figure 12. Plan the Deployment

Things to remember while using *Plan*.

- *Plan* can be run separately or within *WinSC*.
- *Plan* allows you to make choices and see the consequences for the *entire* deployment. Once you decide on the optimum deployment setup, it creates a *Command File* with the commands you will later use to set up the WorkHorse for deployment.
- *Plan* assumes that the WorkHorse is set to its factory defaults (it includes commands in the Command File that put the WorkHorse back to the factory defaults), and it adjusts only a subset of the available commands. Expert users may add other commands to the Command File.
- *Uniform sample times*. Start sample intervals on the minute by using a delayed start up. Instead of having your 10-minute sample intervals start at 15:36:47, delay startup a few minutes to have samples start at 15:40:00.

11.3.2 Set the ADCP's Clock

The second step in the Deployment Wizard will set the ADCP's clock to the computer's time and date using the TS-command. For more information on the TS-command, see the Command and Output Data Format Guide. If you want to skip this step, check the **Skip** box or click **Next** to begin setting the clock.

NOTE. *WorkHorse time* is set from your computer's time. Be sure your computer is set to the time appropriate for your deployments before you use *WinSC* to start data collection.

Figure 13. Deployment Wizard – Setting the Clock

11.3.3 Verify the Compass

The third step in the Deployment Wizard will verify the compass using the AX-command. For more information on the compass verification, see "Compass Calibration Verification," page 20. If you want to skip this step, check the **Skip** box or click **Next** to begin verifying the compass.

Figure 14. Deployment Wizard – Compass Verification

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11.3.4 Run the Pre-Deployment Tests

The fourth step in the Deployment Wizard will run the pre-deployment tests Deploy?, System?, TS?, PS0, PA, PC2, RS, and PC1-commands. For more information on how to test your ADCP, see "Testing Your WorkHorse," page 18. If you want to skip this step, check the **Skip** box or click **Next** to begin the pre-deployment tests.

Figure 15. Deployment Wizard – Test the ADCP

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11.3.5 Send the Commands

The fifth and final step in the Deployment Wizard will send the commands from the command file to the ADCP. Click **Next** to send the commands. When the commands have been sent to the ADCP, you should see a message "*You have successfully deployed the ADCP*." Click **OK**.

NOTE. If you have created a new deployment file, you will be prompted to name the deployment. Choose and use Deployment Names carefully: they help you identify and organize all the data and log files associated with each deployment.

Figure 16. Deployment Wizard – Send the Commands

 The WorkHorse must be using battery power and be sealed, ready for deployment.

 Ping beeps. Whenever the WorkHorse pings, an internal beeper makes an audible beep. The beep consumes negligible energy and tells you the WorkHorse is pinging. If your command file has a Time of First Ping command, the ADCP will wait until that time to begin pinging, and therefore you will not hear it beep.

 View the deployment log file. This file shows all of the commands sent to the WorkHorse and the ADCP's response. If a command generates an error message, correct the problem and re-send the commands.

CAUTION

Do not send a break, any other command, or run any other programs once the commands have been sent to the ADCP or your commands will be over-written.
Disconnect the I/O cable before turning off power to the computer. Some computers may send a break signal out the serial ports when shutting down.

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11.4 Deploy and Recover the ADCP

Figure 17. Deploy and Recover the ADCP

Things to remember while deploying the ADCP.

 Data files are *.SCL (deployment log file) and *000.000 (raw data). For example, if your deployment file is named Test.dpl, then the deployment log file will be Test.scl and the

raw data file will be Test000.000.

 Tilts. The WorkHorse corrects data for tilts as large as 15°, but tilts reduce the effective range and increase the depth of surface contamination.

 Anti-fouling paint. You are free to use anti-fouling paint or other anti-fouling material over any surface of the Work-Horse. However, you should consider the following:

1. Ensure that your coating can be used safely on plastic in general and polyurethane specifically.
2. Apply it thinly and evenly to the transducer faces.
3. Poorly applied coatings on the transducer could adversely affect instrument performance.

 Magnetic material. Keep the WorkHorse's compass away from magnetic material when you deploy the instrument. Check for magnetic fields by smoothly moving a compass around and near the WorkHorse and its mounting frame.

11.5 Recover the Data

DATA
*000.000

Figure 18. Recover the Data

Data are recorded internally on flash memory PC Cards that can be removed and plugged into many PC computers (especially laptops) and read the same as from any hard drive. If your computer is able to read the WorkHorse's flash card, recovering the data is as simple as copying from one disk to another.

However, be aware that because each computer uses different PC Card drivers, installing PC Card drivers on a laptop are not necessarily easy. If you cannot read the memory cards in your computer, use *WinSC* to read the data through the WorkHorse's serial port. RDI can supply or recommend laptops that can read our PC Card flash cards. Remove the flash cards by pushing a button on one side of the PC Card (see Figure 5, page 8). PC cards are installed with the label side toward the face of the transducer.

WinSC reads data files from the WorkHorse PC Card recorder via the serial port and saves the data to the computer's hard disk. It uses the Work-Horse's current Deployment Name to create a new directory for the data on the computer's hard drive. You can specify a different destination directory when you run *WinSC*. When *WinSC* is finished, you will find on your PC all the same files that are on your WorkHorse, and in the exact same format. *WinSC* transfers all data files even if you have recorded more than one deployment. *WinSC* transfers data using an error-correcting protocol (YMODEM), so you can be confident about the integrity of the data files.

11.6 Verify and View the Data

RAW DATA

Figure 19. Verify and View the Data

WinSC rapidly scans each ensemble in your data files and checks them for integrity and quality. Its primary purpose is to ensure that you have properly transferred the data to your computer, but it also does some simple error and problem checking. Keep in mind that *WinSC* does not check every possible problem with your data.

NOTE. Check your data carefully and back it up before erasing the WorkHorse's data recorder.

WinADCP plays back data in a variety of formats (i.e. profiles, time series, and color contour plots). To view the data using *WinADCP*, open the raw data file.

To zoom in on the data, hold down the **Space Bar** and then click and hold the **Left mouse button** to create a "rubber band" selection box. When the mouse button is released, the selected portion of the Whole set is marked by a blinking box outline. The blinking box outlines a set of data called the Selected Set.

NOTE. The Whole Set or Sub Set form must be selected (the title bar color is highlighted) before the space bar is pressed.

11.7 Erase the Recorder

PC CARD
RECORDER

Figure 20. Erase the Recorder

WinSC can be used to erase the data recorder inside the WorkHorse. When instructed, *WinSC* erases all files in the recorder (be sure your data are safely backed up!). If you read the PC Card by putting it into your computer, you may delete the file(s) using the DOS delete command. Before you can delete the file, you must use the DOS attribute command to reset the read-only attribute.

12 Backing Up Data

Once you have recovered the data from your PC Card recorder, you should get in the habit of backing up all data files. Here are several examples of how to backup data.

- Use PKZIP to condense the files and store them on floppy disks. PKZIP has the ability to store large files (span) onto several disks.
- Remove the original PC Card containing data and store it in a safe place. Install another PC Card in its place.
- Backup your data to a CD-RW or other device.
- Download the data to another computer.

13 Reviewing the Data

13.1 'Where' was the Data?

The quickest way to find out the depth of each depth cell is to display your recorded data using *WinADCP*. The velocity display tells you the distance to the center of each cell. The computed distance assumes that the speed of

sound is constant from the transducer to the depth cell. The actual distance is proportional to the average sound speed; if the average sound speed is 1% less than the sound speed at the transducer, the distance to the depth cell is 1% less than the displayed distance.

13.2 'When' was the Data?

The time recorded with each data record is the time of the beginning of the first ping of the ensemble. *Plan* sets the ping interval so pings occur uniformly across the ensemble interval (as opposed to putting all the pings at the beginning of the interval). It leaves a few seconds at the end of each ensemble to allow time for data recording. Hence, the average time of the ensemble is midway between the recorded ensemble time and the time of the next ensemble.

13.3 'What' is the Data?

The WorkHorse records velocity data in units of mm/s. Calibration depends on how well the WorkHorse knew the speed of sound (which it computed based on its measured temperature and the salinity value it was given). A salinity error of 5 ppt introduces less than 0.5% velocity error.

14 A Few Principles of Operation

Consult RDI's Primer (ADCP Principles of Operation: a Practical Primer, Second Edition for BroadBand ADCPs) to learn more about WorkHorse principles of operation. The following are a few points from the Primer that may be worth knowing:

- Horizontal velocity measurement accuracy is unaffected by vertical stratification.
- Stratification has negligible affect on the ability of the WorkHorse to penetrate through the water; concentration of suspended particles is the main factor influencing profiling range.
- WorkHorse measurements are automatically corrected for tilts up to ±20°. In addition to correcting for the beam pointing angles, the WorkHorse maps depth cells to other cells at the same depth.
- If you want to make measurements near the surface from a bottom-mounted WorkHorse, you should minimize the tilt.
- Depth cells are most sensitive to velocities at the center of the depth cell and less sensitive at the top and bottom. This sensitivity is reflected by what we call a 'triangular weighting function'. The details of this weighting function are rarely important for interpretation and use of your data.
- The actual maximum range can be different from the range predicted in *Plan*. *Plan* corrects for range variations caused by temperature and salinity, but it assumes typical scattering conditions. Weak backscatter can sometimes reduce range

by a factor of two or more.

 In self-contained deployments, the maximum profiling range decreases with time as the battery voltage falls. This is because transmit power depends on battery voltage. Transmit power is optimized for about 32 volts. RDI's alkaline battery packs start at 42 VDC, but spend most of their useful lives within a few volts of 32 VDC.

15 Technical Support

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

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Web: www.rdinstruments.com