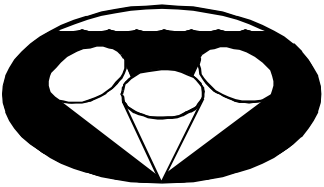

RD Instruments

Acoustic Doppler Current Profilers

Workhorse

Monitor User's Guide

For Real-Time Data Collection

RD INSTRUMENTS
9855 Businesspark Ave.
San Diego, California 92131
(619) 693-1178
FAX (619) 695-1459
Internet - http://www.rdinstruments.com
E-mail - rdi@rdinstruments.com
Field Service - rdifs@rdinstruments.com
FTP - ftp.cts.com/pub/rdifs

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1. Before You Start

This booklet is a short guideline for using the RD Instruments Workhorse Monitor ADCP for real-time current profile data collection. The Workhorse Monitor is one of the Workhorse series of Broadband Acoustic Doppler Current Profilers.

This short guide offers pointers, figures, suggestions, and checklists to save you time and to make your deployment more reliable and effective. It will help you understand the organization and philosophy of our software. It will not explain things that you can easily figure out on your own. We hope you find your time reading this guide to be well spent!

The Workhorse software includes modules for both the Monitor and the self-contained Workhorse Sentinel. Modules specific to the Sentinel's self-contained applications can also be used in many applications with the Monitor. Read for the Workhorse Sentinel User's Guide for more information on self-contained data collection.

Give the transducer faces special care. Any damage to the polyurethane surface could cause the instrument to fail. Consult the Technical Manual for tips to care for your instrument.

1.1 Unpacking

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

1.2 Connection

Figure 1 illustrates how to connect the Workhorse cables and adapters on your workbench.

You will need a container of water large enough to submerge the Workhorse'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.

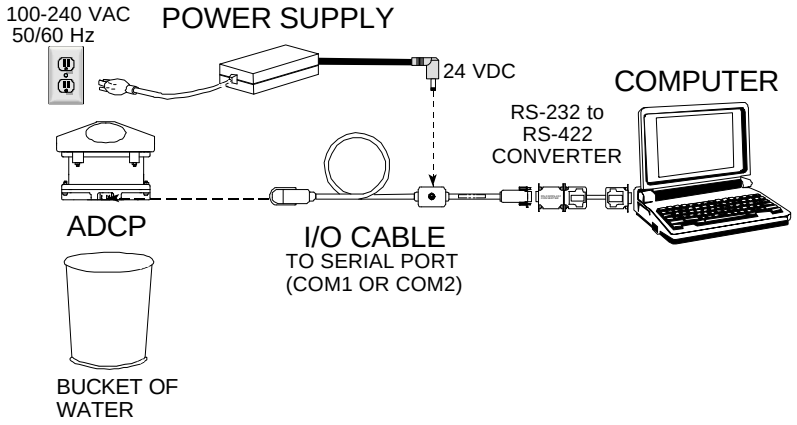

Figure 1. Workhorse Monitor Connections

If your computer's serial port is RS-232, connect the Workhorse cable to the computer through the RS-232 to RS-422 converter (supplied).

1.3 Installing and Using the Software

Instructions for starting the installation routine are on the floppy disk label. Before running *INSTALL*, assemble and connect the Workhorse, cable, and AC supply (see Figure 1).

The installation routine needs the name of the directory that will hold the programs. Unless you prefer a different name, we suggest C:\WH. In the future, change into this directory before you run the Workhorse software.

INSTALL first creates a directory and copies the software into the directory (uncompressing files automatically). *INSTALL* then runs a batch file called *CONNECT*. This batch file connects to the Workhorse, configures the software for the serial port connected to the Workhorse, and runs a simple test so that you know the Workhorse works.

1.3.1 General Guidelines Regarding Software

- Requires 386 or better processor
- All programs run under DOS.
- All assume you have a color VGA display but each can also run in monochrome mode.
- Each has an associated text file that documents the program.
- Each program has a help screen.

The following command line parameters usually apply (when appropriate)

- /? shows you a help screen (except *BBLIST* ?)
- /M displays in monochrome
- /50 displays using 50-line VGA mode
- /Bnnn sets the baud rate
- /COMn sets the expected COM port

1.3.2 Workhorse Software Philosophy

Real-time data collection involves a series of independent steps, each with associated software.

- Test your Workhorse (*TESTADCP*).
- Plan your deployment (*PLAN*).
- Transfer your "plan" into the Workhorse and start data collection (*START-UP*).
- Collect and display your data (*WATCH*).
- Verify data integrity (*CHECKDAT*).
- Play back and process data (*WATCH* and *BBLIST*).

There are several utility programs to help use the Workhorse, each with associated software.

- *RESET* searches for the Workhorse on COM1 and COM2, configures the serial port connected to the Workhorse, but does not run any tests.
- *CONNECT* calls *RESET* and runs a simple diagnostic test to verify the Workhorse's operation.
- *QUIKLOOK* starts *WATCH* using a general purpose velocity display screen.

The Workhorse software is designed to allow you to set up your Workhorse to get the best possible data without having to understand and use Workhorse commands. *PLAN* creates *deployment planning files* (also called command files). These files hold the commands that will be sent to the Workhorse to start the deployment. Curious users may look at the deployment planning files and read about each command in the technical manual. However, few users, whether novice or expert, have reason to change the commands.

1.4 File Naming Conventions

The Workhorse software also does its best to give you a complete record of information that might help you understand your data. This information is stored in text files on the computer's hard drive when it is prepared for a real-time deployment.

To help you associate these files with your data, they use the same deployment name. Where shown, substitute your 5-character name for ABCDE. You will not normally need these files, but they become important if you have a problem or a question about your data. Be careful not to lose these files!

- TESTADCP.DAT - Results from *TESTADCP* are appended to this file.
- ABCDE.TLG - *START-UP* copies the results from *TESTADCP* into this file. *START-UP* assumes that the information in TESTADCP.DAT applies to the instrument you are presently preparing for deployment.
- ABCDE.CMD - Command file created by *PLAN*.
- ABCDE.DLG - Deployment log file created by *START-UP*. This file contains all of the commands sent to the Workhorse (from ABCDE.CMD) and the Workhorse's system information before deployment.
- ABCDExxx.LOG - Deployment log file (where xxx = deployment number).
- ABCDExxx.nnn - Raw data file. Where xxx = deployment number and nnn = recorder card number (incremented when the card is full .000 = card one, .001 = card two). Raw data files will always be paired with a deployment log file (ABCDExxx.LOG).

2. Serial Communication

The standard communications settings are 9600-baud, no parity, 8 data bits and 1 stop bit. You may set baud rates up to 115,200 baud, but if you are using a long cable, we suggest the following procedure:

- Retain the standard power up default 9600 baud rate
- Change to a higher baud rate when you run your software
- Do not make the higher baud rate permanent

This way, if you have a problem at the higher baud rate, you can return to 9600 baud by cycling power. Test high baud rates extensively before you make them permanent.

If you make the new baud rates permanent, most of the software modules will search for the correct settings (and it will also try COM2 but not COM3 or COM4). If you tell the software these settings, you will save time required for searching. If you have trouble connecting to the Workhorse, try *CONNECT* which searches for the Workhorse's current serial port and baud rate and resets the Workhorse to 9600 baud.

RS422. The standard serial protocol for the Monitor is RS422, which is reliable over long wires. The Monitor comes with an RS422-RS232 converter to allow you to connect directly to a computer. You may switch protocol to RS232 by changing a switch setting. The switch is in plain view on the top circuit board, a centimeter or so from the fuse. Its settings are plainly marked on all but the earliest production systems.

3. What If the Workhorse Does Not Respond?

If your Workhorse does not respond, check the serial port, cables and AC power. Try running *CONNECT*. If necessary, refer to the troubleshooting procedure in the technical manual.

If you are running Windows™, try running the Workhorse software from DOS. Try booting your computer with a DOS floppy containing no autoexec.bat or config.sys files.

Workhorse Monitors are shipped from the factory using RS-422 communications! Use the RS-232 to RS-422 converter if your computer does not have a RS-422 COM port. If necessary, refer to the troubleshooting procedure in the technical manual.

4. Power

4.1 AC Adapter

The AC Adapter runs on any standard AC power and supplies 24 VDC to run the Workhorse on your test bench. For real-time data collection, especially over long cables, you should use a 48-60 VDC, 50 W power supply.

4.2 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 either go to sleep or resume pinging.

In the Command Mode

Whenever you wake up your Workhorse, power dissipation increases from less than 1 mw to around 2.2 w. If you leave the Workhorse in command mode without sending a command for more than 5 minutes, the Workhorse 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 you press the reset switch (located on the CPU board), the ADCP will go to sleep.
- If the ADCP receives a CS-command, it will go into the ping mode and begin pinging. If a TF-command 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.

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.

- 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 you press the reset switch, if an alarm is currently set for the next ping, the ADCP will go to sleep. If no alarm is set, 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 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 wait 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.

5. Running Internal Tests

5.1 Software for Testing Your Workhorse.

TESTADCP is a batch file that starts *BBTALK* using a script file. The program wakes up the Workhorse and turns on data logging (records the results) to the file TESTADCP.LOG. We recommend that you save this file by renaming them and moving them to another directory.

TESTADCP runs the following direct commands and displays the result of each test.

- PA - System test (The Workhorse must be in enough water to cover the transducer face during this test, or several tests will fail. Running this test with the Workhorse out of water will cause the Workhorse no harm).
- PC2 - Display heading, pitch, and roll (sensor test).
- RR - Show recorder directory and free space.
- PC1 - Beam continuity test.
- Allows user to enter any other direct commands.

RESET resets your Workhorse to its factory defaults (including 9600 baud), no matter how it is configured nor which baud rate it is set for. It will try both COM1 and COM2 and baud rates from 1200 to 115,200. You can tell *RESET* the current baud rate and COM port to save you the time needed to search for the correct combination. If you wish, you could use *RESET* to set a baud rate other than 9600, to set the Workhorse time to the computer time or to get information about the Workhorse such as the amount of recorded data.

BBTALK is a general-purpose utility that allows you to talk directly to the Workhorse (you can see the Workhorse's help menu by pressing the end key to send a break followed by the "?" key). You can use *BBTALK* to set up the instrument directly, implement built-in tests, and even to collect and record binary data. It is worthwhile to explore *BBTALK's* command scripting capability scripting is a powerful way to automate tasks including starting data collection. The Workhorse software contains several script files (each documented with comments).

You can use *BBTALK* to reconfigure the software for a different serial port or different baud rate. After you start *BBTALK*, use the F5 function key to get a menu that lets you change to the Workhorse's port or baud rate. After you leave the serial menu, press the F6 function key to save the values. The other software will use the saved values when it connects to the Workhorse.

5.2 Running Tests and Interpreting Results

Start tests by running *TESTADCP*, then enter commands directly to the Workhorse. Table 1 lists the tests you can run, gives you guidelines for running the tests and tells you what the results mean. When you are done, rename the log file (TESTADCP.LOG) and save it for future reference.

Table 1. Workhorse ADCP tests.

Test	Guidelines	Results
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.
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.
PC2	Continuously updates sensor display. Rotate and tilt Workhorse and watch the readings on the display change.	Satisfy yourself that the readings make sense.

6. Compass Calibration

RDI's compass can be calibrated in the field without additional equipment because its two-axis tilt sensor and three-axis flux gate compass measure more information than it needs. The additional, redundant information is sufficient to enable internal compass calibration.

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

6.1 Reasons for Compass Calibration

The main reason for compass calibration is battery replacement. Batteries are not a concern for the Workhorse Monitor unless you place an external battery pack close to the instrument.

If you think your mounting fixture or frame has some magnetic field or magnetic permeability, you should run the compass verification procedure and, if necessary, the compass calibration procedure. You must verify and/or calibrate the Workhorse inside its fixture. Depending on the strength and complexity of the fixture's field, the calibration procedure may be able to correct for it.

6.2 Preparing for Calibration

Compass calibration and verification require rotating the Workhorse on a non-magnetic surface. While the ideal place to do this is on a non-magnetic rotating table, these procedures require nothing so complicated. Instead, a piece of strong cardboard on top of a smooth wooden (read: non-magnetic) table will do nicely. Place the Workhorse gently on the cardboard and rotate it by turning the cardboard. This way you will not scratch the Workhorse.

Connect the Workhorse to power and a computer as in Figure 1. You will need no other equipment. These tests require that you send commands directly to the Workhorse using *TESTADCP* (which runs *BBTALK*, wakes up the Workhorse and starts logging to the file TESTADCP.DAT). Be sure to save the log file when you are done.

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

6.3 Compass Calibration Verification Procedure

Compass calibration verification is an automated built-in test that measures how well the compass is calibrated. Start the test with the AX command and follow the instructions. 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. The procedure measures compass parameters at every 5° of rotation for a full 360° rotation. The screen display tells you which directions it still needs. Rotate the Workhorse smoothly and slowly. When it has collected data for all required directions, the Workhorse computes and displays the results. Pay particular attention to the Overall Error.

If you want to verify calibration the good old-fashioned way, use the PC1 command to obtain a continuously-updating display of the current heading and tilt measurements. You can use this output while turning the Workhorse on a rotating table to compare Workhorse compass readings against the table direction.

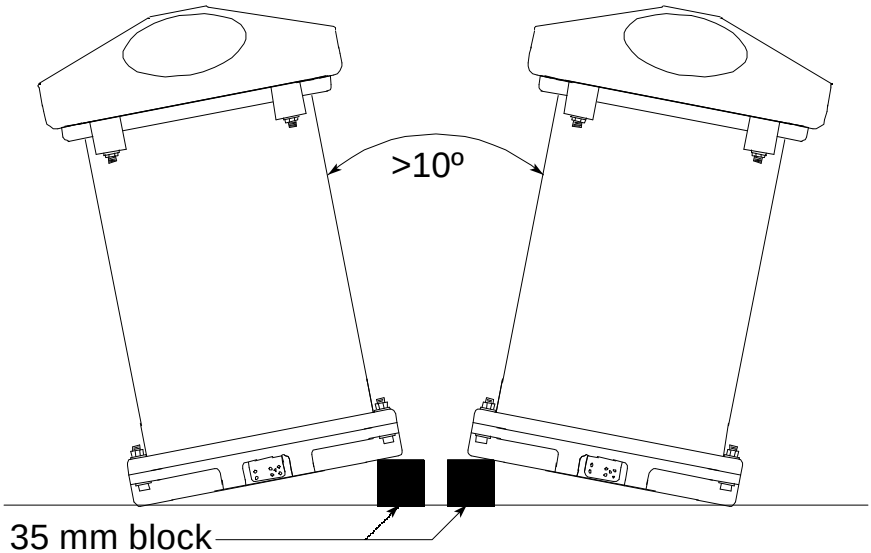

Figure 2. Compass Alignment

Change the Workhorse orientation at least 10° between the first and second calibration rotations.

6.4 Compass Calibration Procedure

The built-in automated compass calibration procedures are 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 the test with the AF-command and choose the calibration type**.**

b. When prompted, rotate the Workhorse slowly 360°.

c. 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°.

d. 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.

6.5 Return to Factory Calibration

To return your Workhorse to the original factory calibration, use 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.

6.6 Read Compass Calibration Matrix

The AD command gives you a listing of the compass calibration matrix. This information is primarily useful for future reference in case you have trouble with data.

6.7 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 Chapter 1.

b. Start *BBTALK* and wakeup the ADCP (press the **END** key).

c. Type **AZ**.

d. Press **ALT-X** to exit *BBTALK*.

7. Deployment Software

PLAN lets you see the consequences of different ways of setting your Workhorse up for deployment. When you are through, it creates a Deployment Planning File with the commands you will later use to set up the Workhorse for deployment. As long as you do not manually change the Deployment Planning File, you can reload and change the file as often as you want.

PLAN assumes that the Workhorse is set to its factory defaults (it includes commands in the Deployment Planning 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 Deployment Planning File, but *PLAN* will not read Deployment Planning Files that contain these non-standard commands.

START-UP sends the commands from the deployment planning file to the Workhorse and tells it to start collecting and transmitting data. *START-UP* is actually a batch file that calls the general-purpose initialization program, *INITADCP*.

Before you run *START-UP*, set the computer time precisely to the time you want to record with your data. *START-UP* uses the computer time to set the Workhorse time. If the Workhorse responds to a command in the Deployment Planning File with an error, *START-UP* tells you which command caused the problem and then terminates.

START-UP creates a log file documenting the commands used to set up the Workhorse, information about the Workhorse itself such as the compass calibration matrix, and a log of the deployment process. This file is given the deployment name with the extension .DLG. A copy is placed in the workhorse software directory on your computer. Be sure to save this file because it contains important information about your deployment.

8. Deployment Guide

Use the following steps and the Quick Reference card to setup the Workhorse for a deployment.

8.1 Prepare the ADCP for Deployment

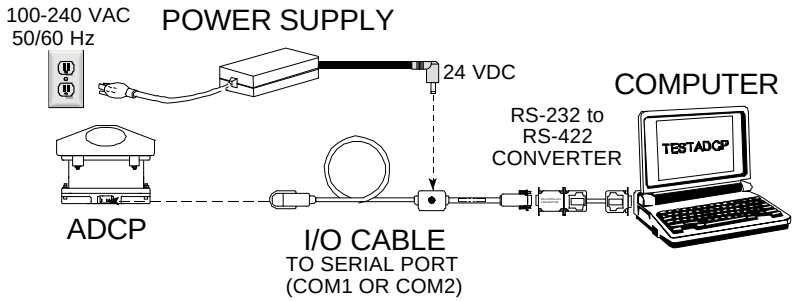

Figure 3. Test the ADCP

Things to remember while preparing the ADCP.

- Test the ADCP using *TESTADCP*. Some tests will fail if the ADCP is not placed in water while the tests are being run.
- Use the Real-Time Deployment Checklist (located on the Quick Reference card) to verify that the ADCP is ready for the deployment.
- *Desiccant* is essential in deployments with plastic pressure cases. The factory-supplied desiccant lasts a year at specified Workhorse deployment depths and temperatures. Remember that desiccant rapidly absorbs moisture from normal room air.
- Calibrate the compass (see Chapter 4 in the Workhorse Technical Manual).
- If you have the optional internal pressure sensor, use the AZ-command to zero it at the deployment site.

8.2 Plan the Deployment

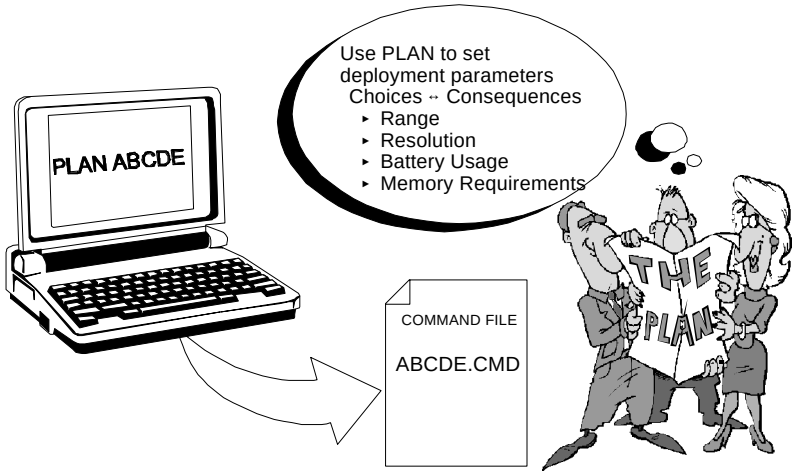

Figure 4. Plan the Deployment

Things to remember while using *PLAN*.

- *Deployment names*. Choose and use Deployment Names carefully: they help you identify and organize all the data and log files associated with each deployment. Remember that the name must be exactly five characters long (substitute your 5-character name for ABCDE).
- *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 *DEPLOY* to start data collection.
- *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.
- *PLAN* allows you to make choices and see the consequences for the *entire* deployment.

8.3 Deploy the ADCP

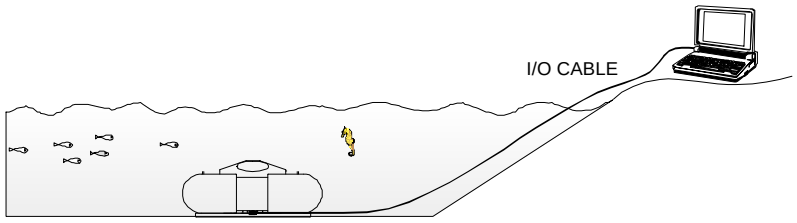

Figure 5. Deploy the ADCP

Things to remember while deploying the ADCP.

- For real-time data collection, especially over long cables, you should use a 48-60 VDC, 50 W power supply.
- *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 any anti-fouling paint or other anti-fouling material you wish over any surface of the Workhorse. 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.

8.4 Send the Deployment Commands

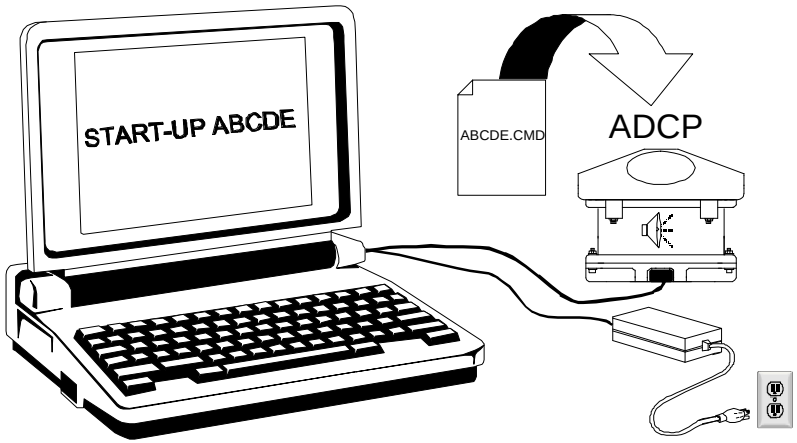

Figure 6. Send the Deployment Commands

Things to remember while using *START-UP*.

- *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.
- View the ABCDE.DLG file. This file shows all of the commands sent to the ADCP and the ADCP's response.
- *START-UP* will start *WATCH* automatically.
- Data files are ABCDE000.LOG (log file) and ABCDE000.000 (raw data) (substitute your 5-character name for ABCDE).

8.5 Data Recording and Display

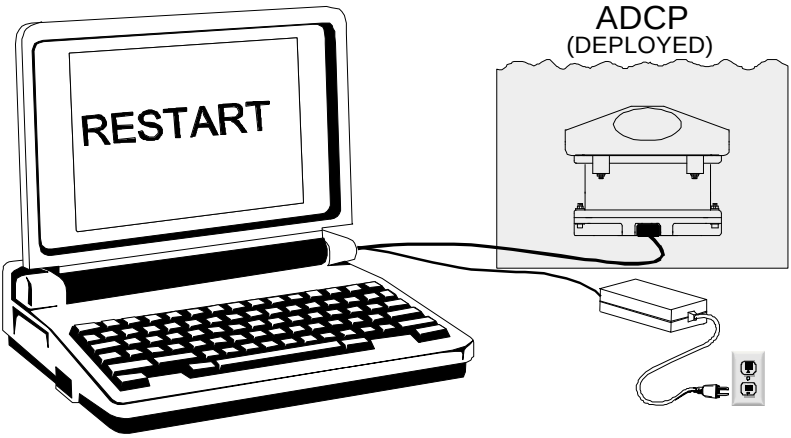

Figure 7. View Data in Real-Time

WATCH displays and records data without doing anything to affect the Workhorse itself; it listens but does not talk to the Workhorse. *WATCH* has powerful capabilities to display data in many different formats, allowing you to change the display as you collect data. Keep your Deployment Name in mind when you record data; remember that your Deployment Name will allow you to organize and find your data later on. If you run *WATCH* and no data appears, double-check the following:

- Serial data connections.
- Workhorse cable.
- Baud rate and COM port number.
- Power connections.
- Did you set "Send data out serial port" on in *PLAN*?
- Has the first ensemble finished recording? Data is sent to the screen after the ensemble is completed.
- Use *RESTART* to resume collecting, viewing, and recording data if interrupted.

8.6 Verify and View the Data

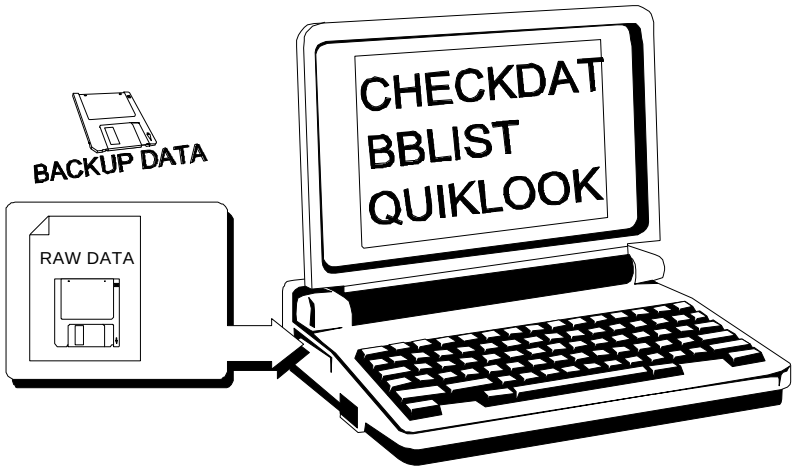

Figure 8. Verify and View the Data

CHECKDAT 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 *CHECKDAT* does not check every possible problem with your data.

BBLIST displays your data in a tabular format in a variety or units and converts the data into an ASCII format you create. People often expect the ASCII conversion process to be complicated and time-consuming. In fact it is easy to use, intuitive and rapid. When you are ready, you should just go into the Convert menu and try it out.

WATCH plays back data in a variety of formats (i.e. profiles, time series, and color contour plots). The easiest way to use *WATCH*, especially when you are new to it, is to run *QUIKLOOK*. *WATCH* allows you to change displays and to save the overall screen design in a configuration file for future viewing.

9. Sending Data to Another Device in Real-time

You can use *WATCH* to send ASCII data out a serial port to another computer or display. *WATCH* uses format files created by *BBLIST* to format the serial output. Hence, you must first learn how to create ASCII files using *BBLIST*. Sample data files included with the Workhorse software ought to be enough to allow you to learn how to use *BBLIST* and to create format files.

Following is the sequence you will use to create and use a *BBLIST* file to output serial data:

- Use *BBLIST* to create an ASCII file with data in a format you like.
- Tell *BBLIST* to save a format file (a file with the extension .FMT). Suggestion: use your deployment name.
- When you run *WATCH*, give it the name of the format file and tell it which port to send data to (run *WATCH* /? to see how to enter the commands).

10. Backing Up Data

Once you have stopped recording data to your computer's hard drive (or the internal 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 (available on RDI's BBS) 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 tape drive or other device.
- Use the DOS backup command.
- Download the data to another computer.

11. Time, Space and Velocity

11.1 'Where' Was the Data?

The best way to find out the depth of each depth cell is to display your recorded data using *BBLIST*. 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.

11.2 '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 that 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.

11.3 '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 commanded to use). A salinity error of 5 ppt introduces less than 0.5% velocity error.

12. 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 15°. 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". You normally need not worry about the details of this weighting function.
- 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 reduce range by a factor of two or more.

13. Technical Support

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

- Phone: 619-693-1178
- Fax: 619-578-4016
- Internet: rdifs@rdinstruments.com
- ftp: ftp.cts.com\pub\rdifs (contains our latest field service bulletins)

If your instrument works and you have questions involving your specific application, you may call either the field service group (above) or our sales/marketing staff.

- Phone: 619-693-1178
- Fax: 619-695-1459
- Internet: rdi@rdinstruments.com (we read our mail every work day at around 0800 local time).