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**An Introduction to the RDI
Acoustic Doppler Current Profiler
as used on Challenger Cruise 15**

by

A L New

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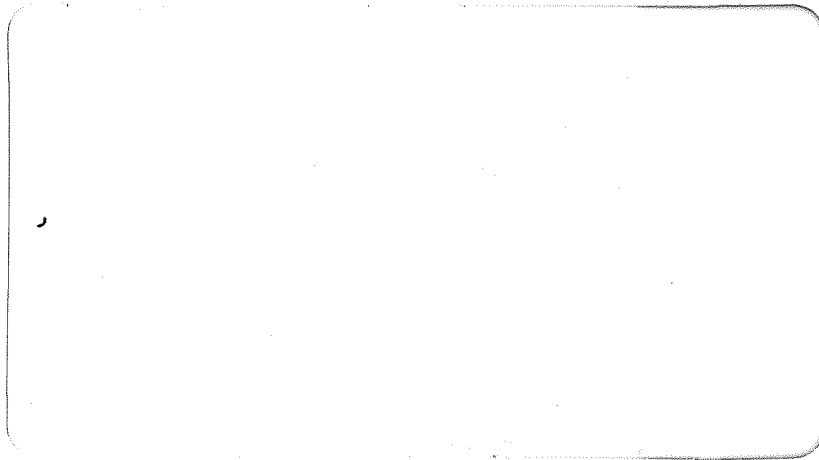
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1. INTRODUCTION

This introduction describes version 2.12 (versions 2.19 and 2.24 have several additional features) of the RDI Acoustic Doppler Current Profiler system as used on the NERC RRS Challenger Cruise 15 (9 May - 5 June 1987), and is intended only as a brief guide from the user's viewpoint. Full details of the system and its operation can be found in the RDI manual, and in case of difficulty contact Robin Powell, RVS, Barry (hardware) or Gwyn Griffiths, IOS, Wormley (software).

The system consists of a personal computer (PC), a deck unit, and four 150 kHz transducers mounted in the ship's hull. The PC has

- (i) F-disk: RAM semi-conductor main memory. (Note that Discovery version 2.12 used a D-Disk instead and that versions 2.19 and following use no RAM disk).
- (ii) C-disk: hard disk, upon which all the programmes and data files are stored (about 25 Mbytes space).
- (iii) A-Disk: drive for high density (HD) floppy disks.
- (iv) B-disk: drive for low (or double) density (DD) floppy disks.

The four transducers are controlled directly by the deck unit. On Challenger and Darwin, two of these point fore and aft, and two point to port and starboard, but on Discovery the beams are set at 45° to the ship's centre line to give better fitting in the sonar pod. Acoustic transmissions ("pings") are sent out as quickly as possible, that is, as soon as the return from the previous ping (from the maximum depth set) has been received and processed. Each return signal is averaged over pre-set depth bins, and then ensemble averaged by the PC over a sampling interval. Because there are acoustic returns from four beams, but only three components of velocity to be measured, some of the data is redundant, and this enables a check on the accuracy of the solution to be made.

To begin, switch on both the deck unit and the PC. The system should then automatically start up in Doppler mode, which is essentially a set of menus. On the screen should be the "main menu", which comprises a set of sub-menus, each identified by, and called by typing in, a two letter code. These menus are used to set up a "configuration", that is, a set of parameters, which will govern the running of the Doppler system. Each sub-menu is exited by typing "X" to return to the main menu, from which "P" will start pinging.

To obtain the PC-DOS (disk operating system) from the main menu, type QQ. This, after pressing the space bar, will give access to the F-disk (prompt F>, version 2.12 only) from which "C:" gives access to the C-disk. This will then enable data to be copied from the hard C-disk to floppy disk with the DOS (see later), and time checks to be done, etc. The Doppler mode can then be restarted by typing "Cntrl/Alt/Del" at the same time. After automatically copying all the Doppler programmes from C-disk to F-disk for easier access, the main menu will then appear on the screen. Note that before re-booting the system in this way all floppy disks should be removed from drives A and B.

Note that, if the terminal does not respond, it can often be restarted by pressing the space bar, or if this fails, by switching the whole system off, then on again.

Finally, if in doubt over the interfaces for the MNS 2000 navigation system, or the ship's heading/gyro-compass input (described below), consult the RVS scientific engineer. Also the ship's second officer should be informed that the outputs of these instruments are being used.

2. SETTING UP A CONFIGURATION

Before operating the Doppler system, it is advisable to set up and save a number of configurations, corresponding to operation in different water depths etc. A configuration is set up by calling the sub-menus AD, DP, DR and SC, and saved by calling SR. Each of the first four of these sub-menus is essentially a list of parameters, all specified by two-letter codes, which will need to be checked and/or changed. Usually, this is done by typing in the two-letter code, followed by the required value, but some "parameters" are simply on/off switches which are toggled by specifying their codes. The most important of these parameters are listed below.

Menu AD (Instrument set-up):

NB: number of depth bins required (between 8 and 128). Usually 50 or 75 is adequate.

SI: sampling interval. This is the time interval over which ensemble averages are performed by the PC, usually 180 secs. being adequate.

- PL: pulse length (between 1 and 32m, in powers of 2). This is the physical length of the emitted sound pulse.
- BL: bin length. This is the depth over which averages are taken, and should take the same value as PL.
- BK: blank zone beyond the ship's hull, an electronically dead area which is to be neglected (usually taken as 3m).
- PE: pings per ensemble in deck unit. Its value should be 1, as all averaging is done by the PC.
- DM: direct memory access. Should be toggled to "yes" so that the IEEE 488 parallel interface between the profiler and the PC operates at maximum speed.
- PS: should be toggled to the "parallel" link.
- PG: percent good data. This flags the ensemble and will not plot it if, say less than 25% of pings are no good. (The system decides upon a bad ping if the return from any bin is outside certain limits, or if the error velocity (see later) is too large. Bad pings are not included in the ensemble average).

Menu DP (Data Processing):

- TP, TR: pitch and roll settings should be "off" for Challenger, but can be selected on Discovery.
- TH : should be "On".
- VS : set to "Yes" to allow velocities to be calculated for the sound speed as defined in the sub-sub-menu SS.
- UR : should be used for plotting velocities relative to a reference layer, defined as the average velocity between bins FB and LB. Note that data stored on the C-disk are always the velocities relative to the ship, but a number of options exist for the graphical display.
- BT : bottom tracking. This plots all velocities relative to the bottom and should always be used whenever possible, that is, in water depths shallower than about 530m. The deck unit sends out a special ping to pick up the bottom when in this mode. Note that the water depth may exceed the actual maximum depth set (NB x BL).
- EV : set to "On" to invoke the error velocity criterion. The system adds the velocities from fore and aft beams (result should be zero), and the same for the port and starboard beams, and if the result is greater than ME, the ping is flagged as being "bad".

- ME : the maximum value of the error velocity for a valid ping. Set to 50cms^{-1} for shallow water (200m), 75 cms^{-1} for deeper water (400m or deeper).
- B3 : solutions utilising just three of the beams are possible.
- PX : set to "No". The PC will then transform the data to ship (XYZ) co-ordinates, rather than the deck unit.
- CS : to calculate velocity standard deviations. Set to "Off".
- BV : set to "Off".
- SS : this is a sub-sub-menu. Check that OD, transducer depth below surface (usually about 3m), and SS, sound speed (about 1500 ms^{-1}) have been correctly set, and that VS is "Yes" so that the velocities are calculated automatically for this sound speed.

Menu DR (Data Recording):

- RD : toggle "Yes" to record data directly to the C-disk.
- AP : automatic pinging. Set to "No". If the system fails, it can then be investigated. Otherwise the system will attempt to restart itself.
- RX-RN : all these parameters should be on "Yes".
- RA : switches in the Automatic Gain Control (AGC). The AGC as plotted by the graphics routines is effectively the strength of the backscattered signal. More precisely, it is inversely proportional to the voltage (gain) applied to the receiver to amplify the return signal.
- PD, SD: set these to "C:" unless no hard disk is available.
- Note that the raw data is in the beam co-ordinates, and is probably not worth recording.

Menu GC (Graphics Control):

- ZV : the zero velocity, for plotting purposes only. This can be toggled to show velocities relative to bottom (B), which should be used if bottom tracking, the mean (M) over the whole profile, the specified layer (L) as defined in menu DP, or the ship (S).
- VL, VH: lowest and highest velocities for plots.
- DL, DH: lowest and highest depths for plots.
- SW : set depth window to over-ride DL and DH.

- GM : graphics mode should be "enhanced" for colour plots, or "high resolution" for black and white plots and for dumping to the printer.
- E : set to "No". Only need to plot the percentage error if the deck unit does ensemble averaging.
- AGC : set to "Yes" to plot the AGC.

It is recommended that plots consist of North/South and East/West velocities (toggle A and B to "Yes"), the error velocity (option D), the average AGC (option G), and the percentage good data (option I). Note that the plots should then be in true geographical co-ordinates since the Doppler programme automatically reads the ship's gyro.

3. OPERATING THE SYSTEM

To start the system pinging and recording, simply type "p" from the main menu (or from certain of the sub-menus). Before beginning to record, however, it is recommended that a number of configurations be set up and stored as work files. Since it is advantageous to use bottom tracking whenever possible (down to 500m approximately), the configuration to be used depends primarily upon depth. One could, for example, set up three configurations as follows:

- (i) for use in shallow water, up to 200m depth. This configuration would employ bottom tracking, plot the velocities relative to the bottom, and could consist of 50 x 4m depth bins.
- (ii) for use in intermediate depth water, up to 400-500m. This could consist of 50 x 8m bins and, employing bottom tracking, would plot the velocities down to 400m. With this configuration, no velocities within the 50-100m nearest the bottom will be plotted as there seems to be interference from the bottom return. This configuration can be used for water depths up to about 530m, at which point the bottom will fail to be tracked and no velocities will be plotted.
- (iii) for use in water deeper than about 500m, when bottom tracking fails. Since the Doppler is incapable of giving good data below about 450-550m, this configuration could use 75 x 8m bins, giving a maximum range of 600m. The velocities can then be plotted relative to the mean (for example).

Configurations such as these should be successively set up and saved as work files using menu SR (save and restore), as follows:

- (a) type EN (enter filename), followed by the chosen filename (or "file prefix") of the configuration which has just been set up.
- (b) type SN to save the configuration to a work file.
- (c) after saving each configuration to a work file, save one (eg. the deep-water example) also to a default file using SV. Whenever the system is restarted, or re-initialised by typing RI from the main menu, the default configuration is automatically set up.

To change configurations, enter menu SR, followed by EN, then the filename of the required configuration (note that the system labels the workfiles as filename.cnf), then RN to read from the workfile.

After entering the appropriate cruise ID, return from the SR menu to the main menu by typing "X", then check that the configuration has been set up as required (eg. check primarily NB and BL in menu AD, BT in DP, and DH in GC), then type "p" from the main menu to start pinging.

Note that at the end of any ensemble the Doppler programme will automatically stop pinging and wait until a navigation fix has been received (via the programmes LORANSNV.COM and USER.COM). These position fixes should come in on every minute exactly (GMT), so it is important to reduce the time the programme is waiting to a minimum. This can usually be done by commencing pinging at "45 seconds" after any exact minute (GMT), whereby the minimum waiting time of about 30 seconds should be achieved.

The programme will display the data graphically at the end of each sampling interval (eg. every three minutes), according to the parameters set in the menu GC, and then commence pinging on the next ensemble. The time remaining in the current ensemble is displayed at the bottom of the screen. This will never be equal to the set sampling interval since about 30 seconds (or more) is usually involved in waiting for a position update. The present position (lat. and long.) is displayed at the right-hand side of the screen, together with the ship's speed as calculated from this position fix and the previous one. Most of the other parameters plotted are self-explanatory, but note that the percentage good data (GD) is based on a linear 0-100% from the left- to the right-hand side of the plot, and that the noise level for the AGC is about one tenth of the way across the screen from the left-hand edge. Finally, if an ensemble data value has been omitted (eg. because the percentage of good data was too low), the graphics routine will perform a linear interpolation.

To stop the system from pinging, simply hit the space bar, followed by "A" (without a "carriage return") to abort, then the "carriage return" after a few seconds. This returns control to the main menu.

4. HOUSEKEEPING

The most important task to perform regularly (eg. daily) is to copy the data files to floppy disk as a backup. All data files are called pingdata.nnn where nnn is the file number. From the PC DOS type "dir pingdata.*" to list all the files on the C-disk. (A new file is started automatically when about 320 kbytes of data has been recorded.) Then proceed as follows:

- (a) format a floppy disk. Insert the disk, label uppermost into drive "a:", for a high density (HD) disk. Then type "format a:". (It is a good idea to format a sufficient number of floppy disks for the whole cruise while still in port.)
- (b) copy each file individually from the C-disk by typing "copy pingdata.nnn a:". This will copy across the file onto the A-disk and retain its name and number. Typically, 3 pingdata files (about 320 kbytes each) can be stored on a single high density floppy.
- (c) type "dir a:" to list all files on the current floppy disk and the amount of storage space remaining.
- (d) remove the floppy, and record the filenames and finish times (displayed by the "dir a:" command) on the label of the floppy. Do not write too hard as this may damage the data!

In this way copy all files to floppy disk, except the one currently in use, which will continue to be written to once the system is restarted. Completed files have file sizes, displayed as a result of the "dir pingdata.*" command, equal to or slightly in excess of 320 kbytes. When a floppy disk is full (ie. contains insufficient space for another file to be written), remove it, seal the write-enable gap with the sticker provided, and insert a fresh disk (which will still be called the A-disk by the system).

Erasing files from the C-disk is actioned by the command "erase pingdata.nnn", whereas "erase a:pingdata.nnn" will operate on the A-disk. Replacing the "nnn" by "*" will erase all the pingdata files on the disk in question.

While in the disk operating system, perform a daily time check by typing "time" and comparing the result with the master clock. It should then be possible to reset the Doppler clock by entering the new time as requested.

Then re-boot the system ("Cntrl/Alt/Del") after first making sure that all floppy disks have been removed.

It is also necessary to regularly check that the ship's heading (present in the graphical display) is being correctly read in from the ship's gyro. Once every two days (when using a synchro gyro, or more frequently if using a stepper gyro interface), compare the two readings every ten seconds over a two minute interval, and then average the result. The two should not differ by more than about 0.5°. At the end of the cruise, obtain a list of the offsets for the ship's gyro from the second mate. (The ship's gyro is regularly checked against star sightings, and should usually be correct to 1° or better.)

Finally, throughout the cruise a log book should be kept detailing how the equipment performed, problems that were encountered, and when configurations were changed etc. From this, a short report should be written at the end of the cruise.

5. ADDITIONAL FEATURES

Menu PB (Playback recorded data):

Playing back of recorded data is possible by entering the PB menu, but only while the system is not recording data. From PB, it is necessary to specify the playback drive (PD option) as either "C:" to playback from the C-disk, or "A:" to playback from a floppy disk. With the other options, it is necessary to specify the required filename, header number (a new header commences each time the system is re-started), and ensemble number for the start of the playback. The time at which this ensemble was recorded is shown by the menu. After choosing either graphical or tabular display, type "G" to start the playback. Hitting the "space bar" will freeze the screen, typing "R" will then resume the playback, or "X" will return to the PB menu.

Printing:

After halting the playback at the desired location, make sure that the printer is "on line". Typing "Shift" and "PrtSc" ("print screen") together will then dump this single screen to the printer. Note that to copy a graphical display to the printer, the graphics mode (GM option in menu GC) should previously have been set to "high resolution", which will give a black and white display. Alternatively, typing "Cntrl" and "PrtSc" together will continuously dump to the printer. To then finish the printing simply repeat the command.

Menu SL (Serial Device):

This menu shows the inputs/outputs to the system. Port 1, for instance, manages the position fixes input to the PC from the MNS 2000 navigation system (at 300 baud), while port 2 is an output (at 9600 baud) to the PDP system, which allows further data analysis and plotting to be performed. The transducers should normally be set to port 0 (which means "de-selected") since the profiler is connected to the PC by a parallel IEEE 488 link. If this link fails, however, then a swap can be made to a serial link by setting the "profiler" to port 3, (or 4) and setting-up the communications settings.

Menu UX (User Exit):

If EE is toggled to "On", at the end of the sampling interval the ensemble will enter the USER.COM programme, where it waits for a position update from the routine LORANSNV.COM. If the position update system is faulty, then switching EE to "Off" and the corresponding port to "0" in the SL menu will circumvent this stage of the procedure

Menu DG (Diagnostics):

If the system seems to be faulty (eg. if the red "bit fail" light flashes brightly and continuously), it can be investigated by entering this menu. The "status byte" is an error flag and if this is not "go" then enter "2" to run test 2 (test 3 is not at present operational). The system tests each beam in turn and reports on errors (the error codes are explained on pages 5.13-5.14 of the manual). The message "low transmitter current" is not a problem provided it is only intermittent. Hit any key twice to stop the testing.

Menu RI (Re-intialisation):

If a "profiler not connected" message appears on the screen while in the main menu, type "RI" to remove it. After re-initialisation, remember that the default configuration will be set up!

Menu H (Help):

This menu gives explanations of the other commands and menus, ie. by entering any two-letter code.

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