

Surface Tracking Feature

1 Introduction

The following Application Note serves as a guide of how to use the LADCP/Surface Tracking mode (also known as ‘WM15’ mode) to track boundary layers such as the air/sea surface and the bottom of the ice layer. It must be noted that tracking these surfaces is not the same as tracking the bottom and so performance is apt to be different depending on the situation. Additionally, the setups described will allow for a “layer of water” to be included in the measurement at the surface or at the under side of the ice layer. It will not necessarily be limited to just the exact boundary surface and may extend several meters below the boundary surface of interest.

1 ADCP Application Background

Teledyne RD Instruments (TRDI) developed a method to measure the speed and direction of the ADCP over the bottom through the use of a specialized ping, separate from the water profiling ping. This technique is called Bottom Tracking (BT). The method and process behind BT is beyond the scope of this Application Note (detailed in the BroadBand PRIMER). What is important to understand from this Application Note is the basic principle, as follows:

1. Transmit a pulse into the water
2. Analyze the return signal for a pattern in the return signal strength (RSSI or Echo Intensity) profile that would indicate a hard surface return. This entails looking for a sudden rise in the RSSI levels above a threshold set in the ADCP (the BA command), making sure that this level stays elevated for a certain minimum time, and then returns to a lower RSSI level.
3. Confirm that the velocity estimate inside the hard surface return provides a correlation value that is above a threshold set in the ADCP (the BC command).

4. Assuming that the above can occur for at least three beams, but most typically all four beams, the ADCP is able to calculate a speed and direction over the bottom.

While BT uses a separate ping (transmit and receive cycle), in 1990 RDI developed an optional feature to couple this processing with the water profile pings. Meaning that instead of just looking for the water profile, the returns from the water profile ping are also processed to detect the presence of a boundary layer.

This process was first developed for, and has been used extensively with, RDI's Lowered ADCP (LADCP) systems. In the LADCP application, ADCPs are installed on a CTD rosette that is lowered through the water column to obtain a full-ocean-depth integrated current profile. Since the rosette is able to freely move and rotate, it is convenient to be able to acquire motion information, when the rosette is near the bottom, to assist in removing the motion of the rosette from the ADCP data. However, both the time and battery energy required for a separate Bottom-track ping to provide motion information to be removed from the water profile data makes its use impractical in this application. As a result, we developed the combined Water Profile and Boundary Tracking ping or more commonly referred to as the LADCP mode for ADCPs with version 8.19 – 16.28 or LADCP/SURFACE TRACK (also known as Water Mode 15 (WM15)) for ADCPs with version 16.30 or higher.

For climate studies, there has been consistent interest in measuring polar ice movement. ADCPs have been used for this application, moored upward-looking under the ice, using the Bottom Track feature. However, since the ice season is long, the energy requirement for BT limited the application to using 300 kHz systems which have less range than desired. Indeed, when Dan Torres, at WHOI, inquired about deploying several WorkHorse Long Rangers (WHLR) to allow deployments further beneath the ice, standard BT was not available for these systems. We suggested the experimental use of the LADCP/SURFACE TRACK mode as an alternative method to track the under side surface of the ice with a Long Ranger. RDI Engineers reviewed algorithms used in our Directional Waves application for surface detection and concluded that the same approach could be used to allow boundary-layer tracking on WHLR. It seemed possible to then use the "LADCP/SURFACE TRACK" feature as a substitute for the standard Bottom-track and gain both great energy savings and the ability to employ a WHLR for this application. We tested the "LADCP/SURFACE TRACK" feature against standard Bottom-track and verified that, while not as robust and quiet as Bottom-track, the "LADCP/SURFACE TRACK" feature could return acceptable bottom range & velocity data under certain circumstances. The concern was that unlike most bottom topographies the under side of ice was anticipated to be very "spiky". This meant that the normal thresholds

for the boundary detection would have to be adjusted. An adjustment was made and the ice was tracked very well during the WHOI deployment. As an added benefit, the deployment was started before there was ice coverage and continued through times of ice and no ice coverage. It was discovered that the new settings did allow tracking of the air/sea surface as well as the bottom of the ice.

Subsequently, we were able confirm that useful range & velocity data can be collected when using the same approach in a "surface Reference Track" application. Because of the difference in reflectivity between ice and open water, although the WHLR could track it, a more adapted set of threshold settings are recommended for the surface layer application as described in this document.

2 Surface Tracking Setup and Use

When it comes to tracking the velocity of the ADCP relative to a boundary layer, there are different solutions provided by your ADCP to achieve what we decided to refer to as 'Surface Tracking':

1. Bottom Track ping: This is usually used with strong backscattering layers such as seabed, concrete wall, ship hull, ice, etc. Bottom Tracking is a separate ping from the water profiling ping. The Bottom Track ping uses a long transmit length to obtain the best possible bottom detection and standard deviation on its measured velocity.
2. Surface Tracking ping: This is usually used with weaker backscattering layers such as air/sea surface, ice, etc. Surface Tracking ping measures both Water Profile and Speed over Boundary Layer in one single ping. This mode offers a considerable advantage over Bottom Track in energy savings when using batteries, but is not as robust and quiet as the standard Bottom Track feature.

Both Bottom Track ping and Surface Track ping provide Speed over the Boundary Layer data which are stored in the Bottom Track Leader in PD0(ID 0006h).

There are two thresholds used in either the BT or LADCP/SURFACE TRACK modes that are set for a surface/boundary detection. The following sections describe the recommended configuration for both modes:

2.1 Bottom Tracking Mode Configuration Setup

BA30

- A raise in the RSSI profile of 30 counts (~15db) is required before the ADCP will start to process the data for presence of the bottom or other boundaries.

BC220

- The correlation of the velocity must be above 220 counts before the ADCP will process the data for velocity speed and direction over the bottom or other boundaries.

2.2 LADCP/SURFACE TRACK Mode Configuration Setup

When the LADCP/SURFACE TRACK mode is installed into your WorkHorse ADCP version 8.19–16.28 the water profile and bottom tracking commands are changed from W commands and B commands to L commands.

With version 16.30–and higher LADCP/SURFACE TRACK mode act as an added feature and hence all other features previously installed on the ADCP remain available such as Bottom Track and Water Profile W commands.

CAUTION. When the LADCP/SURFACE TRACK mode is installed into your WorkHorse ADCP version 8.19–16.28, LADCP/SURFACE TRACK mode will replace all other installed features installed on the ADCP.



Should you still need access to the feature(s) installed on your ADCP together with LADCP/ SURFACE TRACK, you will have to upgrade to ADCP version 16.30-and higher and then install the LADCP/SURFACE TRACK mode.

Upon installing LADCP/SURFACE TRACK, WM command will have to be set to WM15 to enable the LADCP/SURFACE TRACK mode.



NOTE. Note that WM15 command will temporarily disable any access to the Bottom Track 'B-commands' as you can use either Bottom Track or LADCP/SURFACE TRACK but not both.

CAUTION. When the LADCP/SURFACE TRACK mode is installed into your WorkHorse Long Ranger ADCP with version 8.19–16.28 firmware you will no longer be able to use Low Power setting (CQ0). The Long Ranger will be forced into High Power setting (CQ1-CQ255).



When the LADCP/SURFACE TRACK mode is installed into your WorkHorse Long Ranger ADCP with version 16.30 and higher firmware you will no longer be able to use Low Power setting (CQ0) once you sent the WM15 command. The Long Ranger will be forced into High Power setting (CQ1-CQ255).

NOTE. The CQ0 command is accepted by the Long Ranger ADCP in both of the above cases but it is over written internally with no indication to the user. Be sure to plan your deployments in PLANADCP in the High Power Setting.

The thresholds for controlling the ability of your ADCP to lock onto a boundary layer in LADCP/SURFACE TRACK mode is the same as in BT mode except we now only use one command.

LZ030,220

- **030** = The RSSI threshold; a raise in the RSSI profile of 30 counts (~15db) is required before the ADCP will start to process the data for presence of the boundary layer to track from.
- **220** = The Correlation threshold; the correlation of the velocity must be above 220 counts before the ADCP will process the data for velocity speed and direction over the boundary layer.



NOTE. Note in order to detect and track the surface using the water profile you need to set your number of depth cells to a number that will reach at least 20% beyond the surface. For example if you are using 4m depth cells and you are 100m from the surface then you want to use at least 30 depth cells (WN30). Also the range of surface tracking detection is dependent on the depth cell size you use. Larger depth cells will allow for longer ranges of surface track detections.

2.3 Ice Tracking Mode Configuration Setup

This mode will either use a combination of water profile and bottom tracking pings or a single LADCP/SURFACE TRACK ping. The following describes how to set the aforementioned single LADCP/SURFACE TRACK command to allow better detection for a “spiky” boundary, i.e. here the bottom of the ice. If the ice is going to be sheet ice then we would recommend the following LADCP/SURFACE TRACK Mode Configuration Setup.

LZ020,170

- **020** = The RSSI threshold; a raise in the RSSI profile of 20 counts (~10db) is required before the ADCP will start to process the data for presence of the bottom of the ice layer.
- **170** = The Correlation threshold; the correlation of the velocity must be above 170 counts before the ADCP will process the data for velocity speed and direction over the bottom of the ice layer.

2.4 Air/Sea Surface LADCP/SURFACE TRACK Configuration Setup

This mode will rarely use a combination of water profile and bottom tracking pings with success. We recommend using a single LADCP/SURFACE TRACK ping instead when tracking the air/sea surface layer. The following describes how to set the aforementioned single LADCP/SURFACE TRACK command to allow better detection for the air/sea surface layer. If the air/sea surface is going to be irregular (surface ripples, etc.) then we would recommend the following LADCP/SURFACE TRACK Mode Configuration Setup.

LZ015,120

- **015** = The RSSI threshold; a raise in the RSSI profile of 15 counts (~7.5db) is required before the ADCP will start to process the data for presence of the bottom.
- **120** = The Correlation threshold; the correlation of the velocity must be above 120 counts before the ADCP will process the data for velocity speed and direction over the bottom.

3 Example

The following WM15 Surface Tracking example shows the basic steps used to configure your Workhorse ADCP to Surface track.

The following is a basic set of commands that may be used for a WorkHorse Sentinel 300 kHz ADCP and tracking the air/sea surface at 80m from the ADCP:

- 15 bins
- 8 meter bins
- 50 ping per ensemble
- Set the transducer depth as required
- 35ppt
- Set the magnetic variation as required
- Ping immediately after deploy
- Record data internally



CAUTION. When WM15 command is used in a command file, place it after the CR1 command and before any other commands to eliminate the risk of changing a previously sent parameter.

For example, when the ADCP receives the WM15 command, the ADCP automatically changes several commands to LADCP appropriate values. It changes the water profile bandwidth to 6.25 % by setting WB and LW to 1, the number of water profile pings to 1 by setting WP and LP to 1, and the time per ensemble and time per ping to 1 second by setting TE 00:00:01.00 and TP 00:01.00 respectively.

Conversely, when the ADCP has been using WM15 and receives the WM1 command, the ADCP automatically changes the same command parameters to their factory default values.

Example of a WH 300 kHz ADCP with LADCP/Surface Track command file.

```
; Set to factory defaults
CR1
; Set WM15 LADCP/SURFACE TRACK
WM15
; Save settings as User defaults
CK
; Set transducer depth (example is set to 0 decimeters)
ED0000
; Set salinity (example is set to 35ppt)
ES35
; Set system coordinate.
EX11111
; Set one ensemble/hour
TE01000000
; Set 1 minute 12 seconds between pings
TP011200
; Set LADCP/SURFACE TRACK to output Velocity, Correlations,
; Amplitude, and Percent Good. Use LD if firmware <16.30.
WD111100000
; Set 50 pings per ensemble. Use LP if firmware <16.30.
WP50
; Set to record 15 bins (well past the expected surface). Use LN if firmware
; <16.30.
WN015
; Set bin size to 800 cm. Use LS if firmware <16.30.
WS0800
; Sets the minimum correlation magnitude and threshold for
; good surface-track data. Replace 'xxx' with recommended values.
LZxxx,xxx
; Set blank to 176 cm (default value) Use LF if firmware <16.30.
WF0176
; Set max radial (along the axis of the beam) water velocity to 176 cm/sec.
; Use LV if firmware <16.30.
WV170
; Set ADCP to narrow bandwidth and extend range by 10%. Use LW if firmware
<16.30.
WB1
; Set to calculate speed of sound
EZ1111101
; Heading alignment (example is set to 000.00 degrees)
EA00000
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```
; Heading Magnetic Declination Here (example is set to 000.00 degrees)
EB00000
; Record data internally
CF11101
; Save set up
CK
; Start pinging
CS
```

4 Notes

The above settings are not an exact science and performance will vary depending on the environment. We suggest reviewing the recommended command settings to achieve expected performance.

It is strongly recommended to adjust default LADCP/SURFACE TRACK commands with respect to your application, i.e. Ice Tracking or Air/Sea surface Tracking.

5 Acknowledgements

We would like to thank Dan Torres of WHOI for his testing of the LADCP/SURFACE TRACK mode for Ice Tracking so that we could provide a starting point for the Surface Tracking mode.