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# Subject: RDI's Bottom-Tracking

RDI's ADCPs and DVLs offer a diverse range of measurement capabilities. This diversity comes from making four different measurements simultaneously-- two from an acoustic pulse profiling the water column (velocity profile, echo intensity profile), and two from a bottom-tracking (BT) pulse (velocity over bottom, altitude above bottom). In this note, we consider measurements and measurement capabilities derived from the BT pulse.

The fundamental capability enabled by RDI's bottom tracking is making accurate velocity measurements while moving.

- ✓ For ADCPs, bottom tracking permits high-resolution spatial surveys of water currents that can reveal patterns of circulation, impossible to observe any other way.
- ✓ For DVLs, bottom tracking permits highly accurate, precise, and robust navigation, even over terrain as demanding as rugged hydrothermal vent fields on mid-ocean ridges.

## What is Bottom-Tracking?

Bottom tracking is a method for measuring **speed-over-ground** in marine applications. A sonar emits long acoustic pulses that are scattered by the bottom. Determining the Doppler shift in the returned echo provides a measure of the relative velocity between the ADCP or DVL and the bottom. This information is used to provide (1) motion data required by the ADCP for its water-velocity measurements and (2) navigation data to underwater vehicles

These BT pulses are different from the shorter pulses used for water profiling. For ADCP work, the two types of pulses are often interleaved whereas for most DVL work only BT pulses are used. The bottom tracking range is about 2 x water-profiling range.

Whether on vehicles moving along the water surface or fully submerged, the ADCP measures velocity relative to itself--sometimes called apparent velocity. The descriptor **apparent** is in contrast to **actual** or earth-referenced velocities. To derive actual velocities, one must correct the apparent velocity for the ADCP's motion. Two basic situations apply depending on whether the source of the echoes heard by the ADCP is fixed (sea-floor) or moving (water column).

- ✓ For the **fixed** case, which normally applies for bottom tracking, the velocity sensed by the ADCP is caused by its own motion. Apparent and actual velocities are the same except for a change of sign. (Mobile river beds are an exception, e.g. during floods).
- ✓ For the **moving** case, which normally applies for water profiling, the ADCP velocity determined from bottom tracking is used to correct the profile of apparent water velocity to actual values.

Because the ADCP measures both the water motion and its own motion in the same reference frame (defined by its four acoustic beams), several potential error sources affecting the motion-corrected ADCP velocities are eliminated automatically. This is NOT the case when other methods (e.g. DGPS) are used to measure the ADCP motion. Correcting apparent velocities by using data from these other devices requires very careful orientation and calibration to avoid systematic errors in the resulting velocity estimates.

## Key features of RDI's bottom tracking

- ✓ Patented BroadBand™ signalling that enables unmatched precision and accuracy. RDI's Bottom tracking has a typical single-ping accuracy of a few mm/s.
- ✓ Patented single-ping, bottom location algorithm, proven and improved over time to mitigate false detections (e.g. strong scattering layers) and to permit reliable results even in changing seabed conditions and uneven terrain
- ✓ Automatically switching to more precise bottom tracking when altitude diminishes, enabling our ADCPs and DVLs to continue to track the bottom and maintain position accuracy even at 0.3 m range (1200 kHz).

## Other Advantages

Following is a summary list of advantages available to users of RDI's bottom tracking. Items in the list are described in the subsequent sections:

1. Accuracy & Precision
2. Single-ping bottom location
3. Enhanced station-keeping ability
4. Application flexibility
5. Equipment reduction

## 1. Accuracy and Precision

RDI's bottom tracking has significant performance advantages compared with techniques not using RDI's BroadBand technology:

- ✓ X 5 reduction in velocity noise
- ✓ X 2 reduction in systematic "velocity dependent" errors
- ✓ X10 reduction in systematic "velocity independent" errors

## 2. Single-Ping Bottom Location

Accurate bottom detection on each ping means that altitude and vehicle velocity data are immediately available. This provides reliable tracking even in changing seabed conditions and uneven terrain.

## 3. Enhanced Station-Keeping Ability

RDI's bottom-tracking capabilities can be tied in to vehicle control systems, making station keeping as easy as pressing a button. Less noise and less drift means fewer navigation adjustments to the vehicle position as well as excellent station keeping (hover).

## 4. Application Flexibility

- ✓ The superior accuracy and precision of RDI's bottom-tracking permits lower power consumption. In turn, these enable longer duration missions more diverse deployments for underwater vehicles as well as lower operational costs
- ✓ Compared with competing devices, RDI's bottom tracking works much closer to the bottom (30 cm for 1200 kHz), which expands the range of potential operating sites and applications. Maximum bottom tracking altitude is about 20% less than other methods.
- ✓ Even in an upward facing ADCP, bottom-tracking capability has uses: e.g. tracking ice drift or monitoring layover of moorings in strong currents.
- ✓ Bottom tracking allows accurate spatial surveys at river sites that can be in shadow regions for DGPS signals (steeply-sided valleys or river edges covered by tree canopy).

## 5. Equipment Reduction

For many survey applications, (e.g. information about geographical location is not required) RDI's bottom tracking eliminates the need for additional survey devices, e.g. a DGPS receiver and depth sounder.

## Caveats

One general tip for bottom tracking in waters with larger amounts of suspended solids is to operate at a lower frequency if the option exists. The purpose is to reduce the potential for bias or systematic velocity errors in the bottom tracking velocity. Our experience indicates that the difference in water backscatter varies from 6 to 12 dB per octave of frequency – higher frequencies produce louder returns from the water that can degrade bottom tracking in two ways.

(1) The Doppler shift attributed to the bottom echo contains a much stronger contribution from moving water mass near the bottom. The bottom tracking velocity can become biased. In turn, this causes bias in ADCP velocity and discharge.

(2) The water-bottom interface can become difficult to discern in the bottom echo. Water depth becomes uncertain.

## Summary

Built on 18 years of bottom-tracking experience, including conditions as demanding as rugged hydrothermal vent fields on mid-ocean ridges and in near-bottom sediment plumes generated by deep-sea trenching machines, RDI's bottom tracking provides unparalleled accuracy, unique flexibility, and proven results.