Hydrographic Echo Sounder Concepts and Use of the CEE-LINE™ with a GNSS Data Collector for Basic Surveys.

Without an understanding of a few key concepts relating to hydrographic surveying using single beam echo sounders, surveyors are vulnerable to obtaining sub optimum data. This may result from inappropriate equipment setup on the boat, injudicious selection of hardware settings, or unawareness of critical environmental factors. This article describes key points related to shallow water surveys using the CEE-LINE™ echo sounder when connected to a GNSS data collector.

A hydrographic single beam echo sounder uses a short sound pulse (ping), usually at a frequency of 200kHz, to determine the distance between its transducer and the bottom. The time elapsed from the ping's emission to its return is measured and used to calculate the depth. The CEE-LINE echo sounder emits 10 pings per second, each used to separately measure the water depth, with the result being continuously output to the acquisition device. However, the story is a lot more complicated – especially when working in very shallow water, for three main reasons. Firstly, the ping does not just disappear when it is recorded; the sound bounces from the surface to the bottom many times – dependent on the ping "volume", leading to the potential for interference from multiple echoes. Secondly, no transducer can begin to listen for a returned ping immediately; there needs to be a "wait time" and this limits the absolute minimum depth that is measurable. If the bottom gets too close to the transducer, it will become "invisible". This zone is represented by the "Blanking Distance". Third, air absorbs sonar energy very efficiently; there cannot be air entrained under the transducer. The CEE-LINE is continuously modifying its sonic characteristics to track the bottom, and an inappropriate setup can detrimentally affect the depth results obtained.

Boat Installation Considerations for Shallow Water Surveys:

- **The transducer should be positioned as close to the water surface as possible**. This maximizes the measurable depth range. The distance from the water surface to the black urethane transducer face is the **DRAFT**.
- **Air should not be entrained under the transducer**. The depth should be set to just avoid air bubbles. Air bubbles will show up as zero depth spikes and as such are easy to identify. As the boat speed increases, entrainment will increase so data quality may be fine when setting up but could worsen during the survey at higher speeds and this might pass unnoticed.
- **The transducer should be vertical**, or as near to vertical as possible. The transducer beam width does allow for some pitch and roll without detriment to accuracy.

- **Boat echo sounders MUST BE OFF.** The sonar energy from a recreational echo sounder will interfere with the survey echo sounder but will probably not prevent the survey echo sounder *mostly* tracking the bottom. Interference will take the form of random noise overlaid on top of the depth trace. Occasional spurious depths will be seen randomly between zero and the MAXIMUM DEPTH setting of the echo sounder. The noise will show no relationship to the bottom terrain.
- **Echo sounder power should be clean.** Rarely, dirty power supplies can introduce electrical noise and is most likely when high current motor controllers are used on the same power line – for example on a remotely-controlled survey boat.

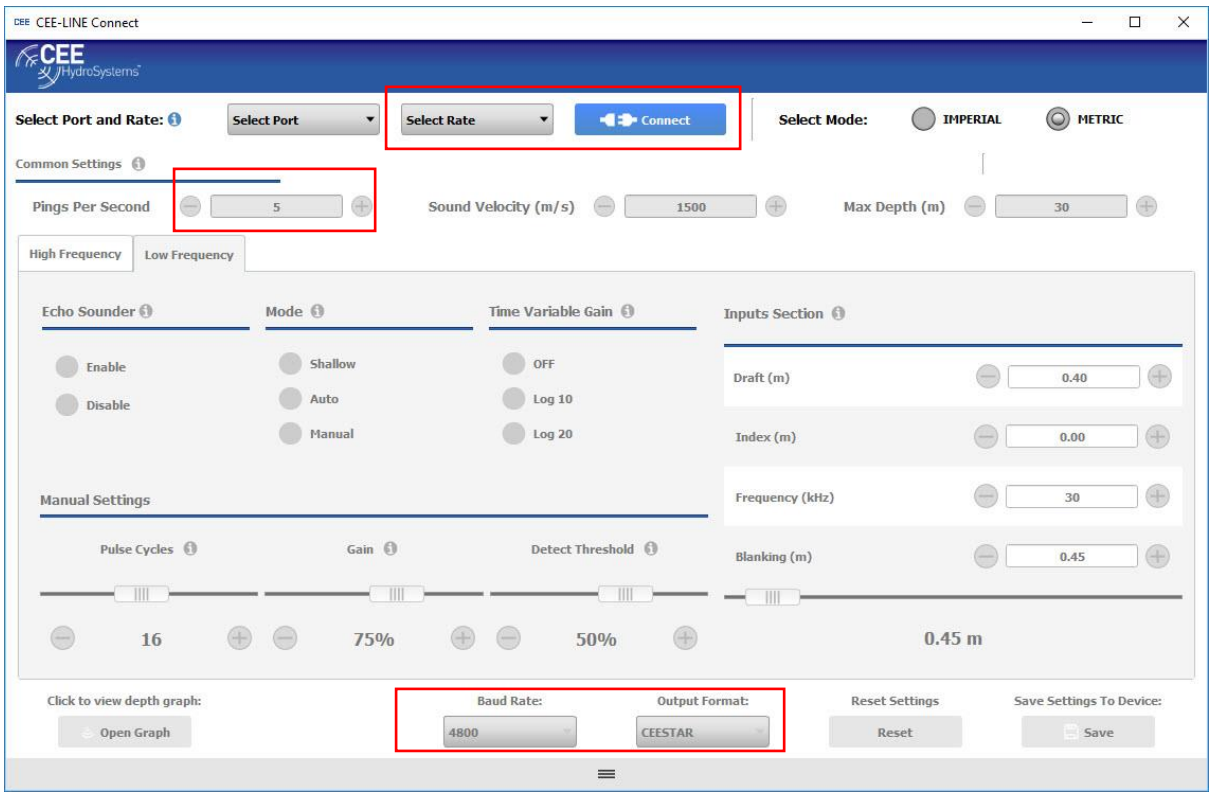
Connecting to the CEE-LINE:

The CEE-LINE echo sounder is configured using the CEE-LINE CONNECT software. Often, this can be done once and left unaltered until surveying in a significantly different environment. The USB cable generates a COM port on the connected PC, and the AUTO baud rate connect may be used to establish a connection to the echo sounder. For field acquisition with a data collector, the following default output settings are recommended. The CEE default baud rate is 9600bps.

Single frequency: **NMEA $SDDBT** (no draft component) Dual frequency: **DESO25** (includes draft)

Maintain **Pings per Second** at **10** to minimize latency with GNSS data.

After settings have been changed, make sure **Save Settings to Device** is clicked. Do not press **Reset**.



Critical CEE-LINE Settings:

- **BLANKING DISTANCE**. This is the minimum measurable distance from the transducer and represents the distance from the transducer within which the bottom is "invisible". For shallow water surveys the blanking distance should be set at the minimum allowable by the setup software, or:
    - 200 kHz – about 30cm / 1ft
    - 33 kHz – about 90cm / 3 ft
- **MAX DEPTH.** This is the maximum measurable distance from the transducer. If the bottom goes below the max depth, no valid results will be obtained, and random noise will be output. The max depth is typically set at about 50% more than the maximum expected depth, and the goal of this is to constrain the depth boundaries to maximize bottom tracking consistency – especially useful in shallow water.
- **DRAFT.** This will add a fixed offset to all depth data. DO NOT ENTER a draft value into the CEE-LINE if a GNSS data collector is being used with a fixed offset already added from the transducer face to the GNSS antenna. This will double count the draft.

Other CEE-LINE Settings:

- **SOUND VELOCITY (SV)**. If you do not know the SV, leave at 1500m/s which allows the post processing correction of depth data if an actual SV is obtained. Otherwise the SV should be entered and recorded in the survey log.
- **TIME VARIABLE GAIN**. Should be always **OFF**.
- **INDEX** should always be **0.00**.
- **FREQUENCY** will be **200 kHz (high)** or **33 kHz (low)**.

Echo Sounder Mode (Bottom Tracking Methodology):

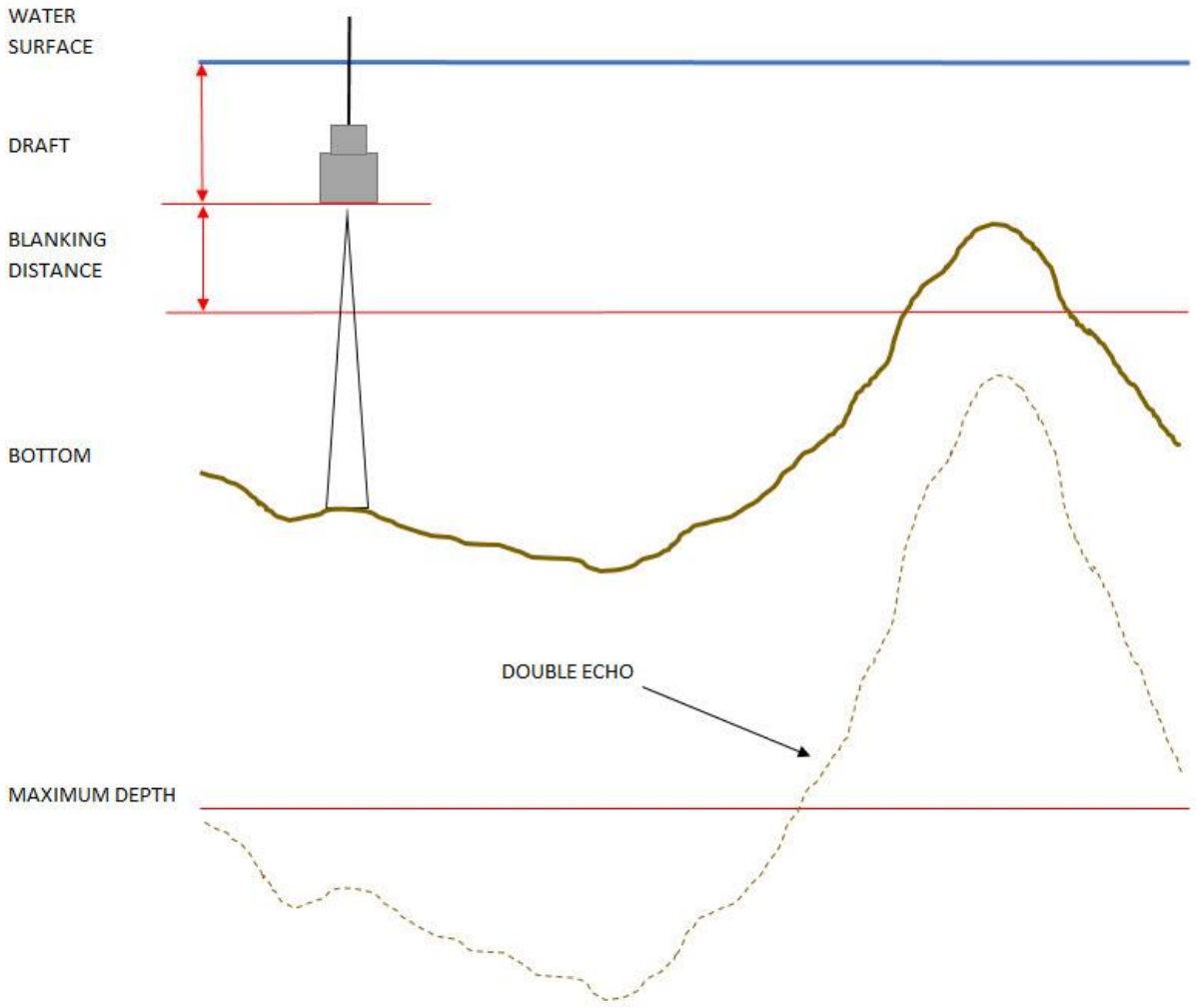
The CEE-LINE can be operated in "MANUAL" mode with allows the user to modify the individual sonic parameters – PULSE WIDTH, GAIN, and DETECTION for unusual circumstances. This mode should not be selected when undertaking GNSS data collector surveys. It requires the use of hydrographic software. Therefore, the user should choose one of these two modes:

AUTO: Standard bottom tracking; the CEE-LINE will use an algorithm to maintain the best combination of settings to track the bottom in the range of 0.3 – 100m (1 – 330ft)

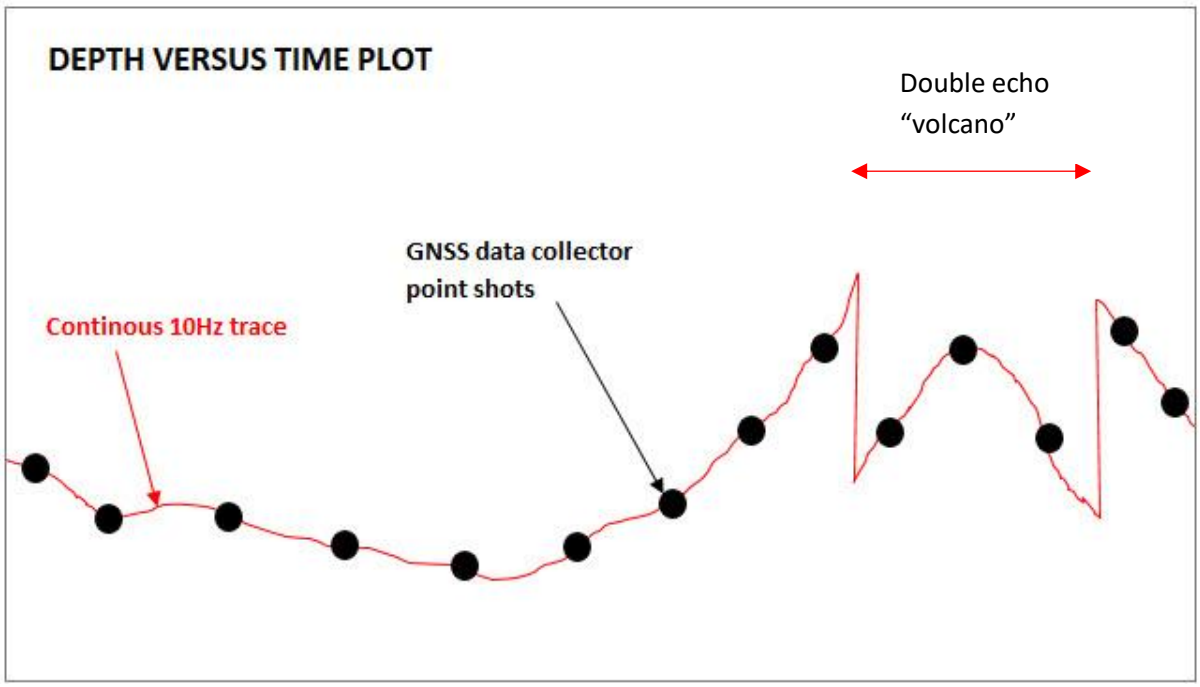
SHALLOW: Modified auto tracking with low power for surveys below 5m (16ft) depth.

Echo Sounder Bottom Tracking Considerations and Impact on GNSS Data Collector Data:

The diagram below represents the key elements of the hydrographic survey. The minimum measurable distance below the surface is represented by the draft + blanking distance. This is irrespective of whether the draft is entered in the CEE LINE software or incorporated into the GNSS antenna offset. Clearly, for extremely shallow water surveys the draft and blanking should be minimized to maximize the depth range that may be surveyed. As the transducer moves left to right along this diagram, the bottom will be tracked correctly. The maximum depth is set well below the survey depth and there should be no data issues – until the point that bottom enters the blanking, "invisible" zone, as is shown on the right side of the trace below. Now the echo sounder has no "real" data to interpret. For reference the position of the potential first multiple sonar return is shown below at exactly 2x depth. This is the trace of reflected sonar energy that may be re-reflected from the surface to the bottom.



So, what happens when the bottom enters the blanked zone? The echo sounder has no valid depth data from the “real” bottom, so the closest return is the first double return. So, the CEE-LINE 10Hz output depth trace shown below will instantaneously switch from the bottom depth to the first multiple return at 2x depth, until the boat moves into deeper water and the bottom moves below the blanking zone and is again detectable. It is up to the surveyor to understand the minimum measurable depth and conduct the survey accordingly. It is impossible to conduct a meaningful survey where much of the area is at the blanking zone, so the boat configuration should be reviewed or improved to minimize the transducer immersion depth.



When data are recorded using a GNSS data collector, it is unlikely that 10 Hz data samples are being collected, and the data visualization will not show the double echo “volcano” as appears above. This is because there is simply inadequate detail to show such a feature. With discrete point shots, the presence of the double echo in the data may indeed be completely overlooked, as is demonstrated above by the data points representing a (say) 1Hz continuous topo measurement.

Also, review of data collected in ELEVATION and not DEPTH may slightly obscure the presence of extremely shallow areas, as it is less obvious that data are close to or within the blanked zone. It’s just slightly harder to keep track of depth data expressed at an elevation of, say, 486ft to 479.5ft than a depth of 0 to 6.5ft. You don’t have to keep remembering that the water surface is at 479.5ft!

CEE LINE Mode Selection:

The depth trace shown on the previous page represents an idealized representation of data that

may be recorded. In the real world, the echo sounder will be continuously trying to reacquire the bottom and the results at or close to the draft + blanking zone may become very scattered and look like noise as the echo sounder switches to registering any one of several multiple echoes (first, second, third etc). If this happens, the bottom tracking lock on the real bottom will take longer to establish once a measurable depth is reached. The echo sounder mode selection affects the performance of bottom tracking around the minimum measurable depth as follows:

Up to but not below the draft + blanking zone depth, the AUTO and SHALLOW modes will provide very similar results and will accurately track into very shallow water. However, after "losing" the bottom into the draft + blanking zone, the CEE-LINE will reacquire the bottom faster in SHALLOW mode than AUTO mode, because of the lower power output range.

For surveys where the depth is under 5m (16ft) and much of the data will be close to the minimum depth, SHALLOW MODE should be selected. AUTO mode should be used in all other cases; if using AUTO mode and the bottom enters the "invisible" zone then the survey boat may be slowed slightly to minimize the along-track distance required to re-establish proper bottom tracking.

The CEE-LINE should not lose bottom tracking under normal operations within the performance specified depth ranges. Occasional spikes to zero will occur resulting from surface debris, occasional air bubbles, or crossing a wake. Occasional spurious spikes or double echo spikes may occur at normal depths however this should represent under 1% of the total data unless there is an equipment installation problem.

Dual Frequency Operation:

The low frequency 33kHz channel is subject to the same blanking zone considerations as the 200 kHz channel except that the "invisible" zone is much wider owing to the increased blanking distance required for the low frequency transducer. So, it should be accepted that low frequency data will be of limited or no value in under about 1m (3ft) water depth.

Unusual Survey Situations:

Hard bottom environments: If the survey area has a hard, flat bottom such as a concrete impoundment or a plastic lined pit, multiple echo reflections may be unusually strong. In this case, ensuring the maximum depth setting is only 25% greater than the expected maximum depth will minimize the potential for extraneous depth spikes from the first multiple echo return.

Sub aquatic vegetation: Heavy vegetation offers a strong sonar signal and echo sounders are not capable of automatically determining the "true" bottom versus the vegetation canopy. Data acquisition using a GNSS data collector should be used with caution in these circumstances and the data sample rate should be set at the maximum, to allow the best opportunity for revealing the bottom through the plant canopy.