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Range Accuracy

One of the simplest questions to ask, yet one of the most difficult to answer is:

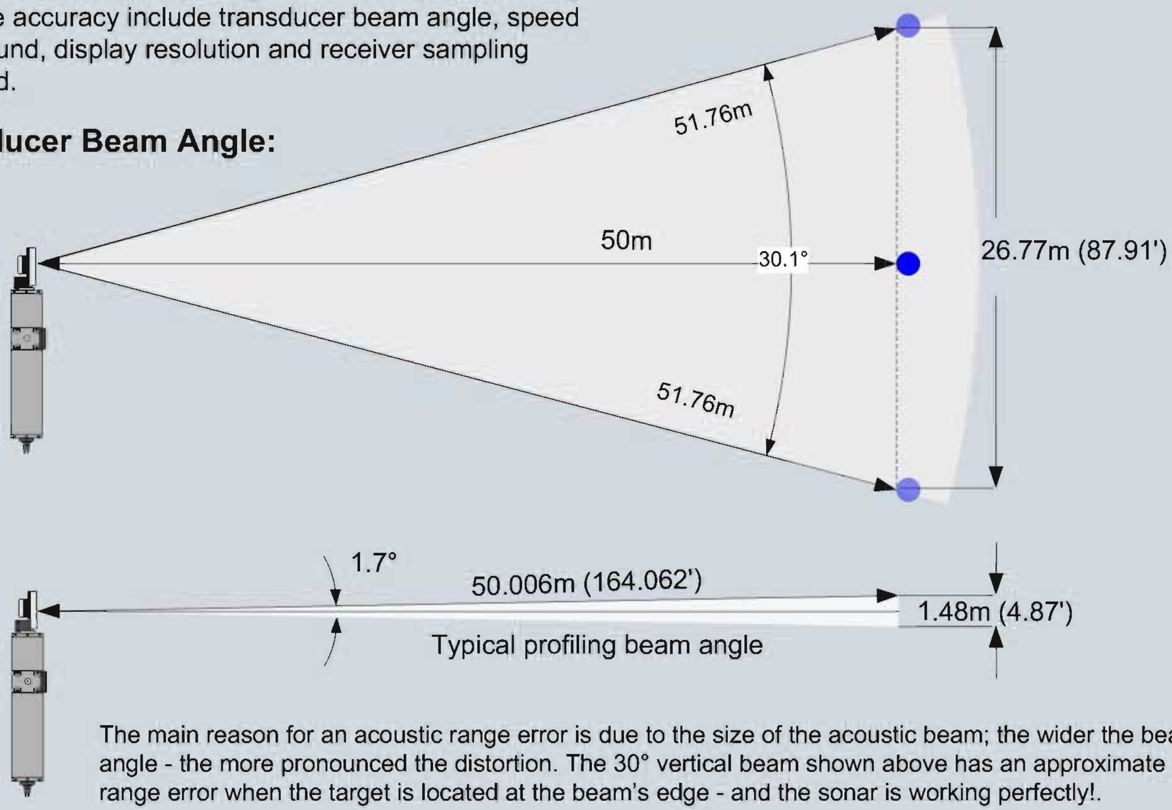
How accurate is the sonar?

To qualify the absolute distance between the sonar transducer and the target includes understanding the variables of:

- Transducer beam angle
- Sonar frequency
- Speed of sound
- Transmit and receiver bandwidth
- Target reflectivity
- Receiver sampling speed
- Background noise
- Display resolution
- Target incident angle
- Target size and shape

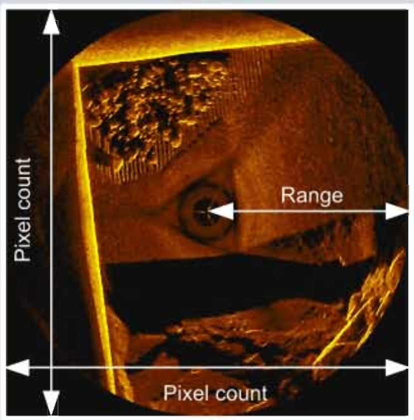
Variables that can be easily qualified when addressing range accuracy include transducer beam angle, speed of sound, display resolution and receiver sampling speed.

Transducer Beam Angle:



The main reason for an acoustic range error is due to the size of the acoustic beam; the wider the beam angle - the more pronounced the distortion. The 30° vertical beam shown above has an approximate 3.5% range error when the target is located at the beam's edge - and the sonar is working perfectly!.

Display Resolution (pixel count):



The number of pixels on the sonar image influences how a range is measured. Assuming the number of pixels for the sonar image is 952 X 952 and the polar image fits across the allotted image area, the selected range (a radius) has ½ the available pixels, or 476. Dividing the range by 476 determines the spatial size of each pixel. When a measurement is taken on the sonar screen it can be no closer than that which represented by the size of each pixel. Note that the display resolution may not match to acoustic performance of the sonar system.

Display Resolution Example:

A 15m polar range scale is selected and the sonar image pixel count is 952 X 952.

Pixel resolution = 15 / 476
= 0.031m

In this example, each pixel is the spatial equivalent of 0.031m (1.22")

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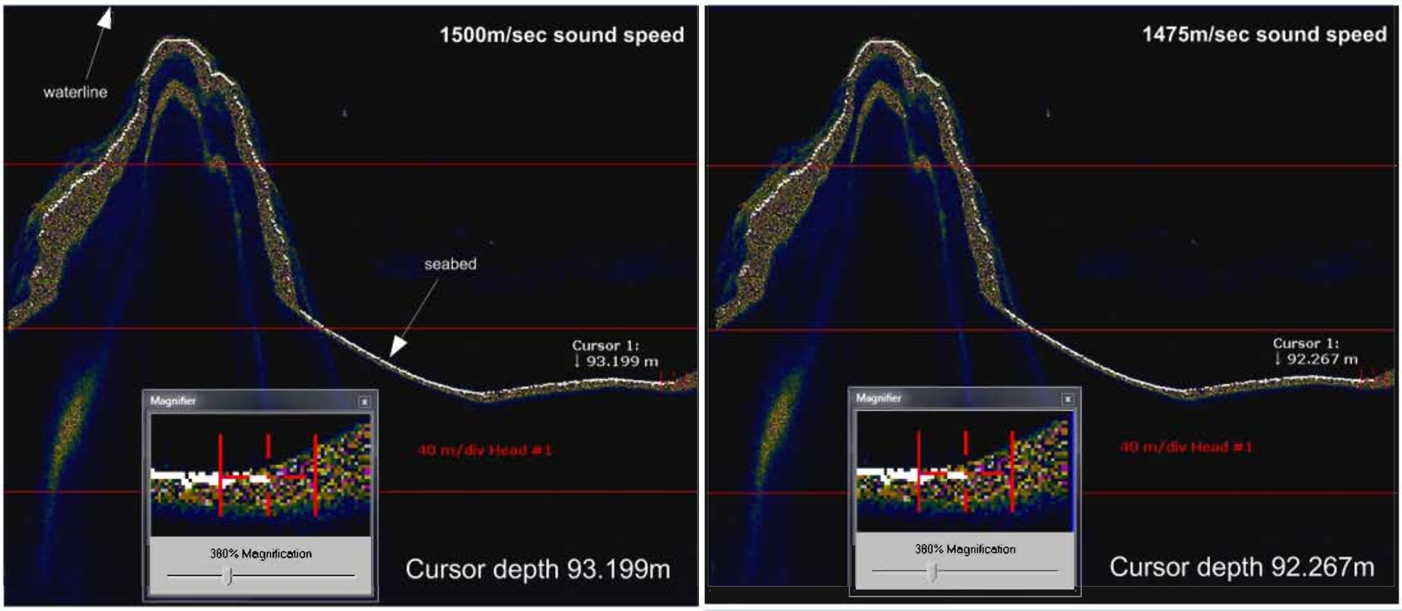
Speed of Sound:

The sonar system only measures time from transmit to receiving the echoed return; to determine range, a speed of sound constant is needed to multiple the time value – and then it it is divided by two to represent a one-way distance. The sound speed varies with changing temperature, salinity and depth. In shallow water, temperature has the biggest impact on the sound speed followed by salinity and pressure respectively. When the wrong sound speed is entered into the program it results in a range error. For every 15m (49.2') difference from the actual sound speed to what is used in the software results in an approximate range error of 1%.



MS 1000 set to echo sounder mode displaying 200kHz altimeter data showing depth results using two different sound speeds

Receiver sampling speed:

"During the receive cycle, the echoed signal is sampled using a very fast oscillator. The faster the sampling speed, the better the system is able to measure the leading edge detection of the target echo (assuming the receiver bandwidth is wide enough to support a wide receiver sampling speed)."

"In many systems, the sampling speed is set to 2.5X (or faster) than the receiver's bandwidth. If, for example, a 12kHz receiver bandwidth is used with an 83μs pulse length, then the sampling rate is typically 30kHz or higher."

The formula used for sampling resolution is: **SR = Speed of sound / sampling speed**

Sampling resolution example:

using a 30kHz sampling speed and 1500m/sec speed of sound:

SR = 1500 / 30,000
SR = 0.05m

If the sampling speed is increased to *300kHz,* the SR values equals *0.005m.*

Many operators confuse the receiver sampling speed and leading edge signal detection with range resolution - which is is the ability to discriminate two targets in range!

Quoted text courtesy Mark W. Atherton, ***Echoes and Images, The Encyclopedia of Side-Scan and Scanning Sonar Operations***