

Review : Bathymetry Mapping Using Underwater Acoustic Technology

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Abstract

The bathymetry mapping using underwater acoustic technology very important in Indonesia waters. Bathymetry is the result of measuring the height of the seabed so that the bathymetric map provides information about the seabed, where this information can provide benefits to several fields related to the seabed. In bathymetry mapping uses underwater acoustic technology where among them is using Single beam echosounder and MBES (Multibeam Echosounder System), and multibeam echosounder (MBES) is acoustic equipment that is intensively used frequently in basic waters mapping.

The advantage of using underwater acoustic technology is the acquisition and processing of data in real time, high accuracy and precision (correction of the bathymetry data was carried out with reference to the 2008 International Hydrographic Organization (IHO), and cannot be a threat or damage to objects. Retrieval of bathymetry data must use parallel patterns, namely: patterns with perpendicular sounding directions and tend to be parallel to longitudinal lines or in accordance with parallel sounding patterns.

Keywords: Bathymetry, Underwater Acoustic Technology, IHO 2008

1. Introduction

Bathymetry is the result of measuring the height of the seabed so that the bathymetric map provides information about the seabed, where this information can provide benefits to several fields related to the seabed, which greatly require bathymetric information such as shipping lanes for transportation and cargo vessels (Morlighem et al., 2017). Bathymetry information on a waters will experience changes without a certain time limit.

Changes in these conditions generally will have a causal factor, namely by several factors such as erosion of the coast by waves, sedimentation, land use in coastal areas, etc (Riadi et al., 2014). Bathymetry is the process of describing the basic waters since measurement, processing, and visualization (Masrukhin et al., 2014). The condition of bathymetry in the waters is very important in relation to the use of space in the coastal area (Rampengan, 2009).

Measurement of bathymetry with conventional methods using the guesswork method, namely the seabed measurement system using cables equipped with ballast pendants whose mass ranges from 25-75 kg (Febrianto et al., 2016). But along with the times and technology, the method has begun to be abandoned, especially in measuring the wide and deep

waters. Current technological developments in bathymetry mapping can be done with acoustic technology, namely by using sound waves so that the use of this technology is better because it does not damage the environment around the research (Lubis et al., 2018 and Lubis et al., 2017).

In bathymetry mapping uses underwater acoustic technology where among them is using MBES (Multibeam Echosounder System) Multibeam echosounder (MBES) is an acoustic equipment that is intensively used frequently in basic waters mapping, especially because this technology has more capabilities namely wide coverage and high resolution for acquisition of bathymetry data (Anderson et al., 2008).

MBES bathymetry is a process of mapping depth of water expressed in terms of depth or depth contours measured against a vertical datum. A bathymetric map generally displays basal reliefs with contour lines called depth contours or isobaths. MBES bathymetry is a process of mapping the depth of water expressed in terms of depth or depth contours measured against a vertical datum (Adi et al., 2017).

2. Theory of Operation

In theory, the use of underwater acoustic technology for bathymetric mapping by optimizing

the bathymetry survey will greatly depend on the speed of the ship in making a measurement. The maximum vessel speed in the cast (u) is allowed according to the standard of the ability of the equipment to reach 100% coverage of the seabed along the track direction, that is by using the value of the speed of sound (C), wide of fore-aft ϕ and the width of the vessel gap (2θ) from the existing radiation pattern, and the slope of the ocean floor α in the direction of the survey path (Figure 1) and the maximum speed on the ship (Figure 2).

In the application of bathymetry mapping using underwater acoustic technology, there are factors of value and its relation to the speed of the ship when conducting activities in the waters. The values ϕ start from $0,5^\circ$ until $2,66^\circ$, which provides information that the speed of the ship is more than 12 knots (6 m/s) which can be achieved by front-rear position beamwidth $0,5^\circ$ or larger for warships that have a basic slope up to 45° . In casting activities, sea conditions or the condition of the ship's speed and the length of the track along the routine will be greater than 100%.

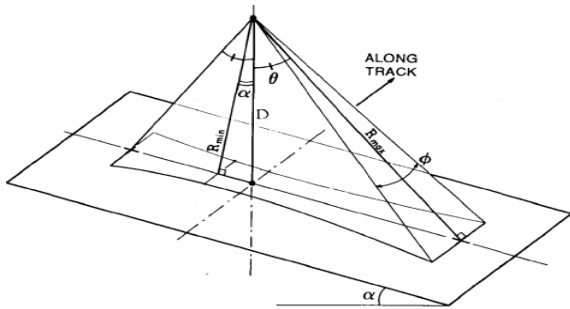


Fig 1. Geometry ensonification on a sloping basis (Moustier, 1988).

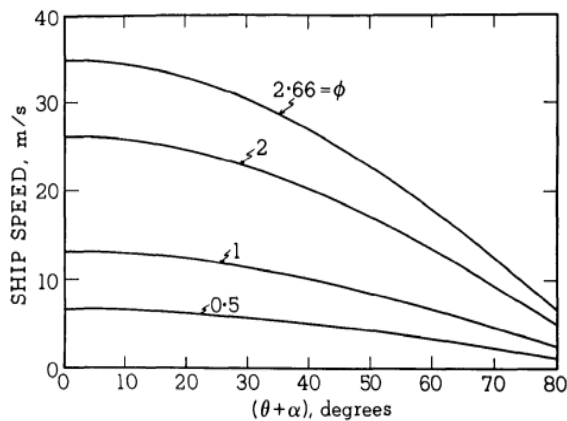


Fig 2. Maximum boat speed (or 100% coverage with short or high frequency reflections) (Moustier, 1988).

Each transducer used for seafloor mapping has a sending system that emits an acoustic pulse signal with certain characteristics or codes, so that the signal reflected from the bottom of the water is only received by each recipient transducer as shown in Figure 3, and illustrated taking bathymetry data using

a single beam and multibeam echosounder can be seen in Figure 4.

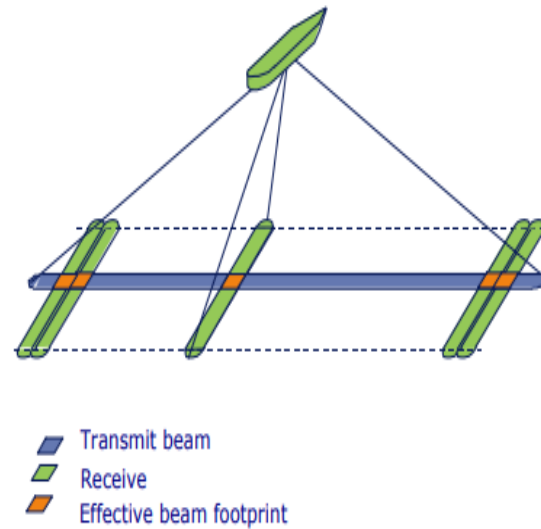


Fig 3. Geometry illustrations in bathymetry data extraction using the multibeam echo sounder.

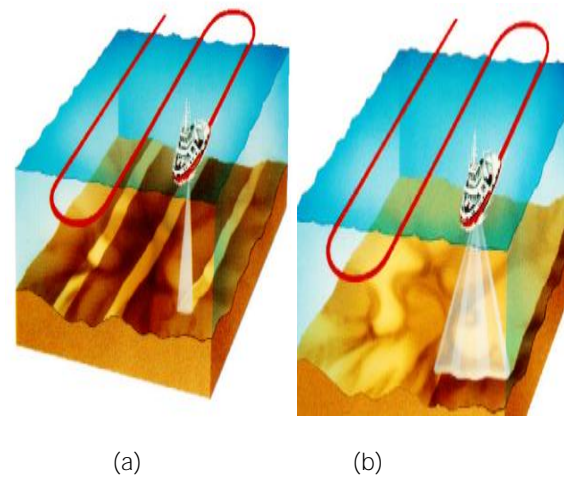


Fig 4. (a). Illustration of taking bathymetry data using single beam echosounder, and (b). Illustration of taking bathymetry data using multi beam echosounder (MBES).

3. Bathymetry Data Correction

The level of accuracy obtained from data from the bathymetry result is the main thing that must be known, because there is a relationship with the value of accuracy or accurate level of data to provide information on the bathymetry value of the seabed actually in the water. With this, the data obtained is in accordance with predetermined standards, so it is necessary to control data quality in the form of correction of data on bathymetry data. Correction of the bathymetry data was carried out with reference to the 2008 International Hydrographic Organization (IHO).

If correction of the bathymetry value after the data has been obtained, it will be corrected by bathymetry by calculating the deviation of depth at the point of

analysis, which is found at the intersection between the transverse and longitudinal paths expressed as the error (s) based on the equation as follows:

$$s = dl - db \quad (1)$$

Information:

s = Depth error

dl = Depth of analysis point on transverse path

db = Depth of analysis point on longitudinal path.

The magnitude of the error value of the bathymetry results in data collection in water will be limited based on the standards set by IHO (2008), ie it cannot exceed the tolerance limit of 2σ . This provision has been based on the values of a and b contained in the minimum standard table for hydrographic survey activities (Table 1).

Accuracy standards in measuring bathymetry activities using special order underwater acoustic technology must be used in critical water conditions, such as shallow waters with slurry bases which have muddy sediments; order 1a is a shallow water area that has a depth of the seabed that is less than 100 meters, with a distance below the keel of the ship which has been affected by a smaller critical area; order 1b is a shallow water area of less than 100 meters, ie the distance below the keel of the ship is not considered by the critical area again with factors including the expected surface type area; while order 2 will be applied to the depth of an aquatic waters more than 100 meters or deep waters (IHO 2008).

IHO Standards of Hydrographic Surveys is a standardization or technical reference issued by IHO (International Hydrographic Organization). IHO Hydrographic Surveys SP-44 in 2008 is the latest standardization that has undergone renewal (IHO 2008). In this 2008 IHO SP-44, measurements of depth tolerance were carried out. If the error value in different depth data is still within the tolerance limit obtained by calculating formula (1), then the quality of depth data goes into the tolerance limit which refers to the 2008 IHO Standards of Hydrographic Surveys SP-44. beyond tolerance, the depth of quality does not enter the tolerance limit. Table 1 is the standard for accuracy of water depth measurements (IHO 2008).

Table 1. Standards for accuracy of water depth measurements.

Orde	Spesial	1a	1b	2
Depth Detail	a = 0,25 m b = 0,0075	a = 0,5 m b = 0,013	a = 0,5 m b = 0,013	a = 1,00 m b = 0,023

The process of calculating the error limit or tolerance limit error in measuring bathymetry in a waters will refer to the IHO standard (2008), which is mathematically using the equation:

$$\text{Limit error } (\sigma) = \pm \sqrt{[a^2 + (b \times d)^2]} \quad (2)$$

Where :

a = Constant constant error (m)

b = Non-permanent depth error factor

d = Measured depth (m)

b x d = Error in depth which is not fixed (m).

Correction of bathymetry data of water will determine the accuracy of the bathymetry data used to determine the position of a target or determine a ship's shipping lane. Some of the depth points used in making corrections to the bathymetry data are determined based on the intersection point of the gridding milling path.

This aims to be able to find out how much deviation or error detection is in the same position at different times. The error value of each water depth correction point does not exceed the tolerance limit set by IHO (2008).

4. Underwater Acoustic Technology

Underwater acoustic technology that will use the hydroacoustic method while this method has several systems, one of which is the single-beam echosounder system, which is an air enhancement measuring device that uses a single beam system to buy and receive sound signals (Snellen et al., 2011).

This system measures air depth directly from ship surveys (Brouwer 2008). In general, Singlebeam has a component transceiver on the hull or bearing side of the ship. Transceiver transfers acoustic pulses with certain frequencies contained in the beam directly down the air column while in the pathway (Lubis and Anurogo, 2016; Lubis and Pujiyati, 2016).

Before carrying out oceanic mapping or bathymetry activities using underwater acoustic technology, the raw data obtained from SONAR will be collected for each ping in a beamformed and the range of objects or bathymetry values detected (Roman and Singh, 20015).

This range detection will be achieved by looking at each beam and making selections in the range of peak amplitude returned to the receiver from the transducer.

To reduce the possibility of this error, which has a relationship with the return of very weak signals, the beam does not overwrite the bottom and other false detection with the range sent using the amplitude threshold value and median filter with neighboring beams, this can be seen in Figure 5.

The resolution owned by SONAR has a maximum range value that will carry out a pulse transmission process with a fixed duration of time (τ) which is determined by the bathymetry axis as long as the reflected volume will be returned from individual reflections that cannot be distinguished, with the following equation:

$$\Delta r = C\tau/2 \quad (3)$$

where C is the speed of sound, which will be considered with acoustic backscatter values obtained with various distances in bathymetry in the waters, Illustration of the beam obtained in this case can be seen in Figure 6.

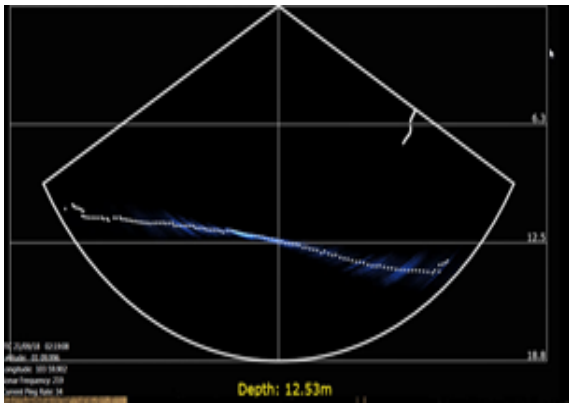
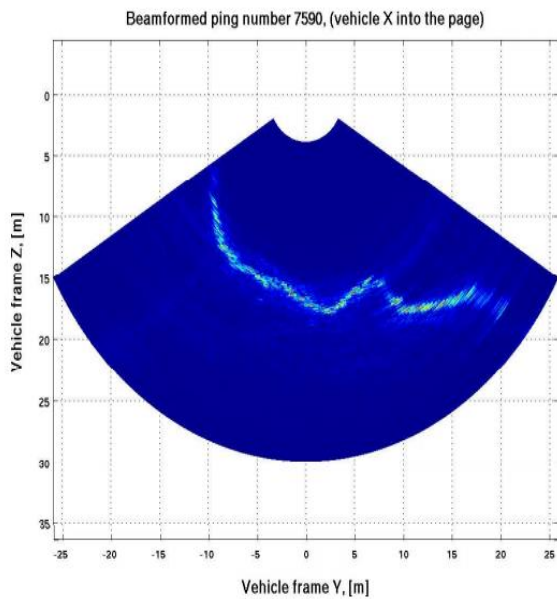


Figure 5. Sample single ping obtained from multibeam sonar which can be formatted and plotted as intensity images in 2D Cartesian space.

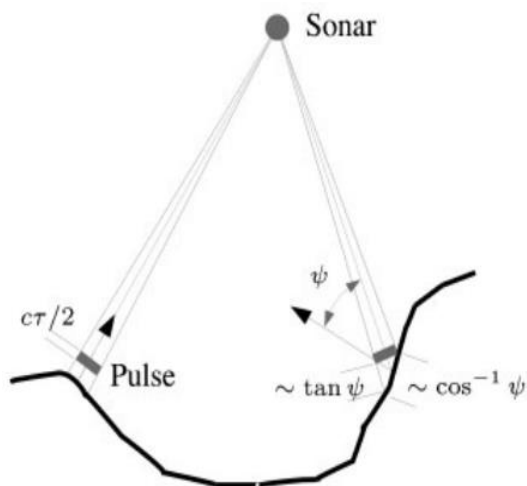


Fig 6. Dependence on the back scattering angle is spread out, with a sketch showing normal and grazing incidence.

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