DETERMINATION OF SPATIAL ORIENTATION OF SOUNDING VESSEL USING FLOATING CORE FLUXGATE

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ABSTRACT

Determination of spatial orientation of sounding vessel is an essential problem from determination of acoustic wave reflection points in geodesic bathymetric surveys radiated by an echosounder point of view. Pitching, rolling and yawing as a result of wind, wavy motion and vessel movement determine the outlet angle of acoustic wave, trajectory of acoustic ray as a result of refraction, location of reflection point and determined depth on the basis of the distance between the transducer and reflection point measured by the echosounder.
In the paper possibilities analyse of floating core fluxgate's application for determination of spatial orientation of sounding vessel have been presented. Compensation of pitching and rolling have only been presented because of sensor limitation.

INTRODUCTION

Achievement of the depth measurements' high accuracy and of the position determination with a use of satellite techniques does not guarantee achievement of the hydrographic survey's high accuracy, although the measurements are not easy. They are accompanied by many processes and phenomena which decrease the accuracy and reliability if not taken into consideration. In general, factor having impact on the measurements' accuracy may be divided into two basic groups: of those resulting from dynamics of sounding vessel and of those that are related to environment.
As a result of interferences, the following actions are connected with a moving sounding vessel:

- **pitching, resulting from wavy motion, wind as well as change of the vessel's speed,**
- **rolling, mainly resulting from wavy motion and wind,**
- **yawing, i.e. change of the sounding vessel's vertical position, resulting from impact of waves.**

For determination the spatial orientation are used accelerometers, there can also been used positioning systems with specific antenna's configuration or satellite compasses. New, alternate solutions, especially as regards economic one, are searched.

DUAL AXIS FLOATING CORE FLUXGATE

Floating core magnetometers are primarily for measuring the horizontal component of the earth's magnetic field to make compasses. Because the earth's field has a vertical component which varies around the world, the floating core fluxgate devices always resolves only that part of the field which influences a core which is held in the horizontal plane. Autonnic's range includes both damped and undamped types as well as 3 sizes: for tilt angles of +/- 20, 35 and 45 degrees.

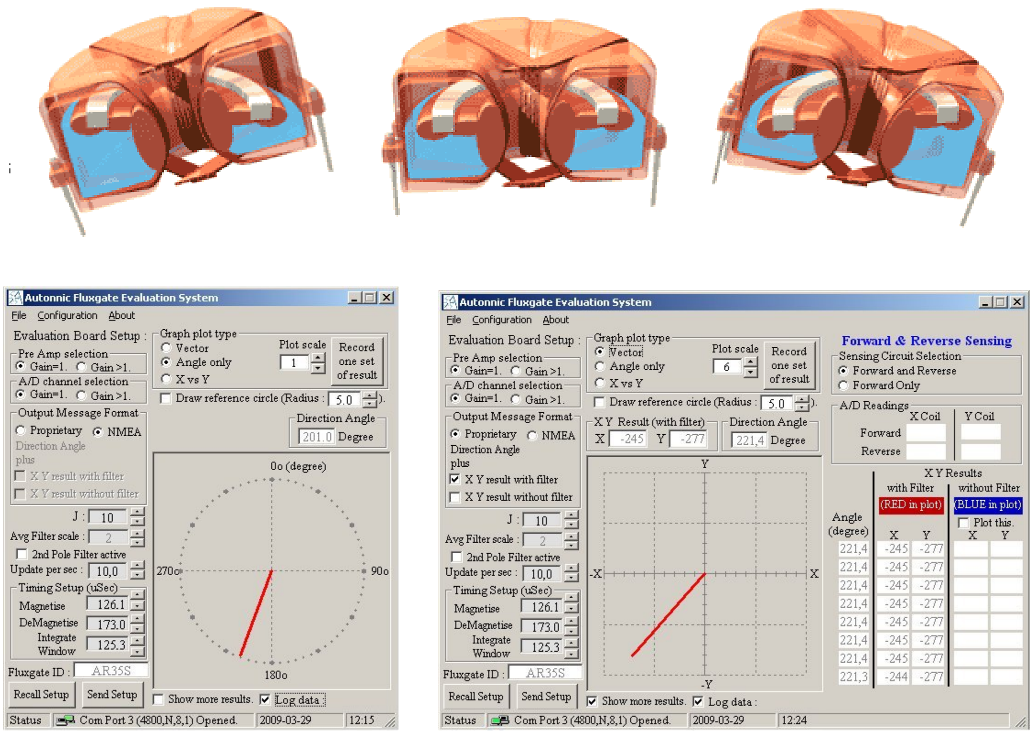

Fig. 1. Floating core fluxgate sensor and Autonnic's application.

DETERMINATION OF POSITION OF ACOUSTIC WAVE REFLECTION POINT

Let's have the positioning system, making - together with an echo-sounder the hydrographic system, extra equipped with one receiving antenna enabling determination of positions of two points P_2, P_3 in respect to the geocentric reference system connected with Earth and these points determining a vector with a point of origin n, and then, in the next step a vessel free vector p_1 of coordinates

$$\begin{bmatrix} p_1^X \\ p_1^Y \\ p_1^Z \end{bmatrix} = \frac{n}{|n|} = \begin{bmatrix} \dfrac{n_X}{\sqrt{n_X^2 + n_Y^2 + n_Z^2}} \\ \dfrac{n_Y}{\sqrt{n_X^2 + n_Y^2 + n_Z^2}} \\ \dfrac{n_Z}{\sqrt{n_X^2 + n_Y^2 + n_Z^2}} \end{bmatrix} \tag{1}$$

This vector is a direction vector of a straight line crossing point P_1 which in special case - shall be a mounting place of the echo-sounder's transducer.

Fig. 2. Location of antennas an transducer with three colinear points method.

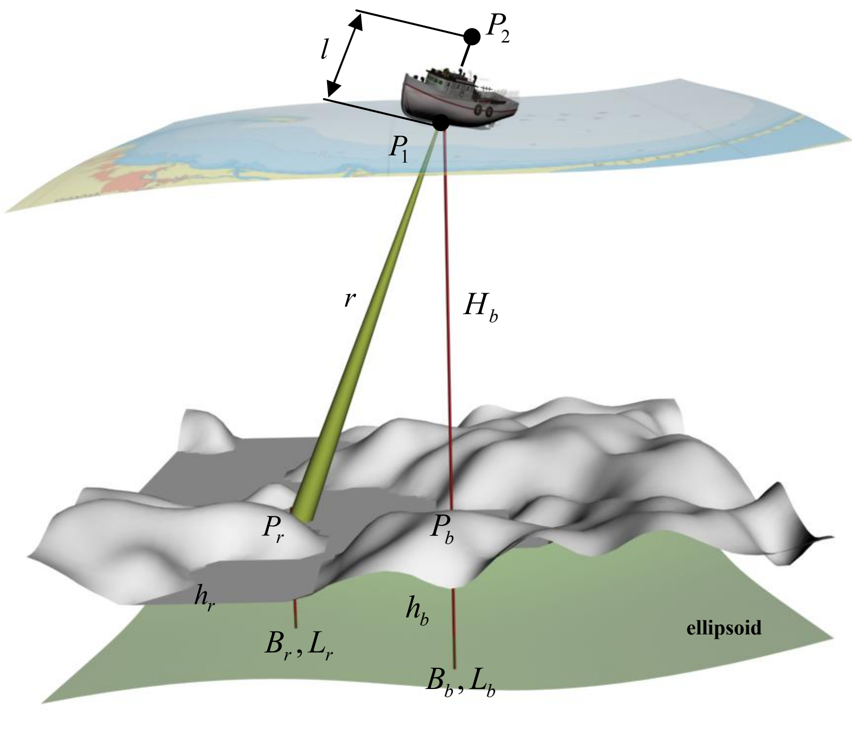

Fig. 3. Location of antennas and transducer with floating core fluxgate.

That is why determination of position of the measuring point P_b (defined with the originated vector in respect to $\Im^E = \{O^E, (e_x^E, e_y^E, e_z^E)\}$, from which the acoustic wave reflects, can be executed based on known coordinates of direction vector of the straight line crossing the points P_1 and P_b, and position coordinates of one of the antennas, e.g. P_2, according to the dependence:

$$\overrightarrow{P_2 P_b} = \begin{bmatrix} (l+r)\cdot p_1^X \\ (l+r)\cdot p_1^Y \\ (l+r)\cdot p_1^Z \end{bmatrix} \quad (2)$$

$$\overrightarrow{O^E P_b} = \overrightarrow{P_2 P_b} + \overrightarrow{O^E P_2}, \quad (3)$$

where: $P_b = [X_b \quad Y_b \quad Z_b]^T$, l - distance between the antenna P_2 and the transducer P_1, r - distance between the transducer P_1 and the reflection point P_b, - the depth measured by the echosounder.

For determination of the position of acoustic wave reflection point, for sensors not positioned along symmetry line of sounding vessel, there is necessary to use a course sensor, for example the floating core fluxgate.

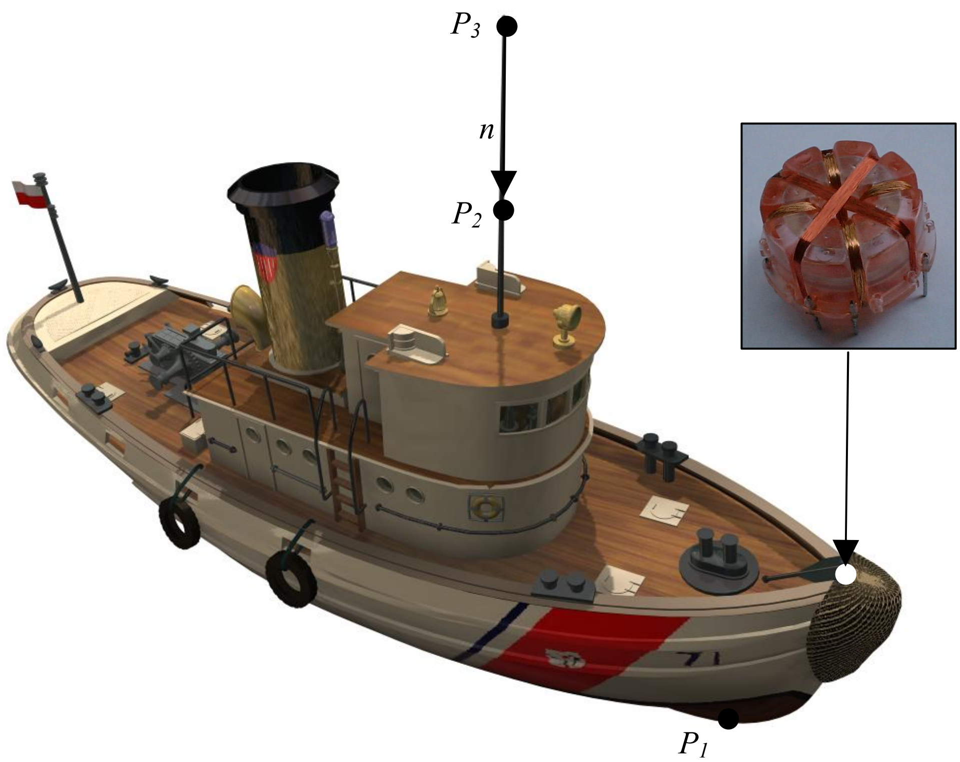

Fig. 4. Location of antennas and transducer with floating core fluxgate.

Position of acoustic wave reflection point can be calculated on the basis of following equation:

$$\overrightarrow{P_2P_b} = \begin{bmatrix} \sqrt{\Delta x^2 + \Delta y^2} \cdot \cos\left(KR - arc\,tg\dfrac{\Delta y}{\Delta x} \right) \cdot p_1^X \\ \sqrt{\Delta x^2 + \Delta y^2} \cdot \sin\left(KR - arc\,tg\dfrac{\Delta y}{\Delta x} \right) \cdot p_1^Y \\ (l + r) \cdot p_1^Z \end{bmatrix} \qquad (4)$$

Where *KR* stands for a real course of the sounding vessel obtained using floating core fluxgate, x and y are offsets of location of the antenna P_2 with respect to the transducer P_1.

CONCLUSIONS

The system for hydrographic surveys shall consist of the positioning system, single-beam echo-sounder and instrument measuring the sound speed in water, however theoretical considerations of the acoustic wave's trajectory and determination of its reflection point are valid for elementary beams radiated by the multi-beam echo-sounder. The area regarding determination of movement disturbances has been solved thanks to the multi-sensor positioning system. It is an alternative for accelerometers used in the hydrography for determination of pitching, rolling, and yawing. Usage of fluxgate type magnetic devices with floating cores or of GPS-Compass – a two-antenna GPS system capable of measuring direction - may be another possible solutions for determination of the movement disturbances.

The latter solution requires development and an additional antenna of the GPS system due to capability of measuring only one angle: of pitching or rolling, depending on orientation of the devices in respect to symmetry line of the sounding vessel.

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