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POSITION'S ACCURACY DETERMINATED BY MEANS OF ACOUSTIC METHOD

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The main goal of this paper is to shown the accuracy zones of hyperbolic system. This system has been used for underwater source localisation. The location of underwater object with relation to the antenna array influences on errors values. Optimal configuration of the antenna array assures the least errors values and the largest operation zone.

INTRODUCTION

Localisation of underwater objects is possible by means of measurements of hydroacoustic signals, which are radiated by these object. Using estimation methods of time delay between signals, which reach the receiving array is possible to determine of object's position in the bearing- distance system. It is the hyperbolic system, where the position is deteminated in a intersection point of position lines- hyperboles. Depending on object's location with relation to the receiving array, the position's accuracy by means of this method is not equal. In this paper quantitative description of position's accyracy and accuracy zones of navigational hyperbolic system have been described and distribution of constant accuracy lines has been shown for hypotetical receiving array.

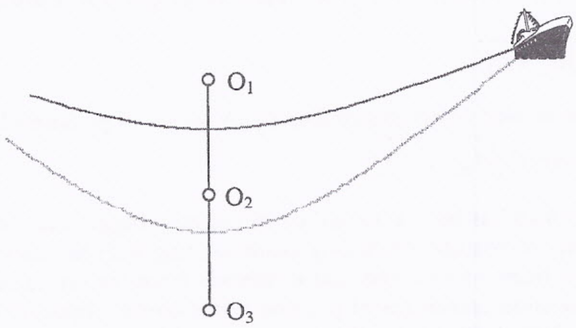

Fig. 1. Object's position in hyperbolic navigational system

1. QUANTITATIVE DESCRIPTION OF POSITION'S ACCURACY

Positions accuracy at the sea is shown as the flat figure. Probability of position's locating inside this figure depends on position lines' probability.

When we accept, navigational measurements errors have the normal distribution, the measure of the position lines errors dispersal is the standard deviation σ_{lp}.

$$\sigma_{lp} = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} \tag{1}$$

The probability, that position lines errors are inside $\pm\sigma$ is 68,27%. The error which describes standard deviation of the position line is measured from the mean average, which has been detremianted by means of many observation in this place and time.

The object's position is determinated in the intersection point of two position lines, where each of them can be obtained with different error

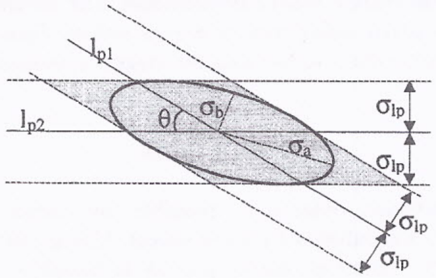

Fig. 1. The relationship between position accuracy sizes

The shape of errors' elipse changes itself with changes of σ_{lp} position lines errors' quantity and θ angle of their intersection.

The dependence between M mean error of position determinating and semiaxises of mean errors' elipse is practical used for determinating of object position's accuracy:

$$M = \sqrt{\sigma_a^2 + \sigma_b^2} \tag{2}$$

The M quantity can be also determinated directly by means of positions lines errors:

$$M = \operatorname{cosec}\theta\sqrt{\sigma_{lp1}^{\ 2} + \sigma_{lp2}^{\ 2}} \tag{3}$$

The circle's area, which has been enclosed by M radius is bigger than the area of mean error's elise, so probability of position's situating inside the ring with M radius is greater than inside the elipse and it is from 0,63 to 0,68 and it depends from the errors elypse semiaxis' ratio. For example, the location probability of position inside errors' elipse for k=1, 1,5, 2, 2,5 and 3 is adequately 0,39, 0,68, 0,86, 0,96 i 0.99.

2. ACCURACY ZONES OF HYPERBOLIC NAVIGATIONAL SYSTEM

The accuracy zone area is called the area, which is delimited by the line, where the position mean error is less than the assumed error. The value of position mean error by means of the hyperbolic system can be calculated by means of (3). The values of position lines errors are follows:

$$\sigma_{lp1} = \frac{\sigma_{\Delta d}}{2\sin\frac{\omega_1}{2}} \qquad \sigma_{lp2} = \frac{\sigma_{\Delta d}}{2\sin\frac{\omega_2}{2}} \tag{4}$$

The angle θ can be expressed by means of angles:

$$\theta = \frac{\omega_1 + \omega_2}{2} \tag{5}$$

Generally M can be written by means of (3) and (4):

$$M = \sigma_{\Delta d} \cdot k \tag{6}$$

where: $\sigma_{\Delta d}$ – mean error of navigational parameter measurement,
k – geometrical rate of hyperbolic system:

$$k = \frac{\sqrt{\sin^2\frac{\omega_1}{2} + \sin^2\frac{\omega_2}{2}}}{2\sin\frac{\omega_1}{2}\sin\frac{\omega_2}{2}\sin\theta} \tag{7}$$

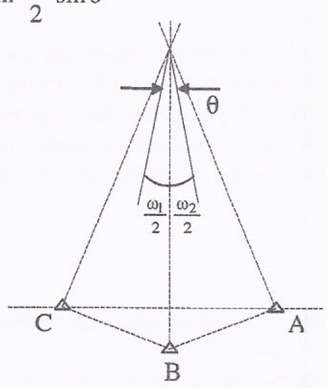

Fig. 2. Dependences between angles in hyperbolic navigational system

Each of the accuracy zone is characterized by follows:

- the range with the least acceptable accuracy,
- the size with the least acceptable accuracy,
- the area which is determinated by means of constant accuracy lines.

Fig. 3 shows constant accuracy lines for the hypotetical receiving array, where hydrophones are stright at 50 m distance.

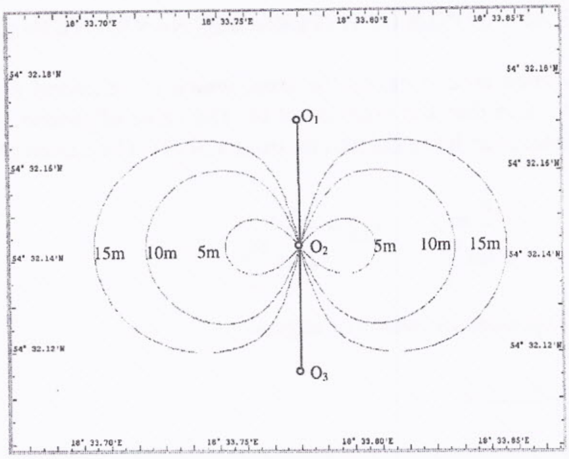

Fig. 3. Constant accuracy lines of hyperbolic system

3. CONCLUSIONS

During designing of navigational system we try to achieve one or some of following tasks:

- to get the greatest operation zone in the direction;
- to get the greatest area of the operation zone;
- to get the greatest accyracy in concret area;
- to get the greatest area which is characterized by the greatest accuracy.

The main stage of system designing is the analyse of accuracy zones, which are determinated for different location of receivers. For presented the receiving array, the greatest operation zone can be obtained by increasing of distance between hydrophones. Is necessary to use another hydrophones to decrease position errors on the base (the line, which connects hydrophones).

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