High-Precision Technologies for Hydro-Acoustic Studies of Complex Bottom Relief are One of the Areas of the Special Economic Zone of the High-Tech Park

Nataliia Punchenko
dept. of automated systems and cybersecurity
Odessa State Academy of Technical Regulation and Quality
Odesa, Ukraine
iioonn24@rambler.ru
ORCID 0000-0003-1382-4490

Mariia Levkovska
dept. of Hygiene and Medical Ecology
Odessa National Medical University
Odesa, Ukraine
Levkovskaja46@gmail.com
ORCID 0000-0003-2016-8567

Oleksandra Tsyra
dept. of communication Networks
O.S. Popov Odesa National Academy of Telecommunications
Odesa, Ukraine
Aleksandra.tsyra@gmail.com
or ORCID 0000-0003-3552-2039

Valentina Solodka
dept. of communication networks
O. S. Popov Odesa National Academy of Telecommunications
Odesa, Ukraine
valyaonas@gmail.com
ORCID0000-0002-5357-6682

Galyna Kovalova
dept. of mathematics
Odessa State Academy of Civil Engineering and Architecture
Odesa, Ukraine
gkovalova@ukr.net
ORCID 0000-0003-2228-2312

***Abstract*—Consideration is given to the processing of hydro-acoustic data recorded using depth gauges in combination with navigation information sensors. Particular attention is paid to multi-beam echo sounders. To improve the efficiency in the processing of measurement information time interpolation is performed.**

Keywords—multi-beam echo sounder, depth measurement, navigation information sensors, sonar

I. INTRODUCTION

Comprehensive knowledge of the World Ocean with aim for the use of its resources is one of the global problems of an innovative society. To accomplish this task, along with a compass and lags as well as number of the basic technical means for navigation ensuring the safety of navigation for ships, various types of distance meters basically hydro-acoustic are used. Depth gauges are multifunctional and widely used on ships of various activities and warships.

The creation of multi-beam echo sounders brought this problem to a qualitatively new level. With the advent of high-precision certified integrated systems of the new generation, which use the latest design solutions in the development of acoustic emitters and in the creation of new digital signal processing technologies, have become the most effective means for conducting hydrographic work, since as a result of their use, material and time costs are significantly reduced due to expanding the bandwidth and increasing the amount of data collected.

II. THE ERRORS PRESENT IN THE MEASUREMENTS

The main function of depth gauges is to ensure the safety of navigation for vessels of all classes. This task is particularly relevant today, when in the world becomes more complicated due to the increase in the number of large-capacity vessels, the decrease in their maneuverability, and the increase in their draft. In connection with the improvement of the design of ships, the number of depths dangerous for navigation increases, all the more so since the fleet is required to work in all water areas and under any navigation conditions to solve transports problems.

In order to ensure the safety of navigation, for depth meters, attention should be focused on improving such characteristics of navigation depth measurement tools as: accuracy of readings and measurements, degree of automation, and reliability. We must remember that correctness of results is determined by the fact that they do not contain errors. Effective results are methods of solving problems, etc., which provide an error-free solution of problems [1]. It should be borne in mind that no hardware improvements can completely eliminate the errors present in the measurements, which are determined by a number of factors. Since modern echo sounders can only work in conjunction with sensors of navigation information and information about the spatial orientation of the carrier vessel, next to the errors introduced by the echo sounder, it becomes necessary to take into account the measurement errors of these sensors, which, significantly, affect the quality of the source information, especially conducting deep-sea measurements [2]. It is also necessary to introduce corrections

for the refraction of acoustic rays during their propagation into a non-marine marine environment. It follows that the search for new approaches to the organization of effective information systems to assist in navigation is a promising way to improve the general safety of navigation [3].

Improving the efficiency of navigation echo sounders in modern conditions is impossible without considering the section of science that is rapidly developing at the present time, and undoubtedly has a great future - a hydro-acoustics. The appearance of which was preceded by a long path of development of theoretical and applied acoustics. The first information about the manifestation of human interest in the spread of sound in water is found in the notes of a famous Renaissance scholar Leonardo da Vinci: “If you, being at sea put a pipe in the water, and to put the other end to your ear, you will hear ships far away”. Hydro-acoustics is a section of acoustics that studies the emission, reception and propagation of sound waves in the aquatic environment (in oceans, seas, lakes, etc.) for the purposes of the underwater location. The main feature of underwater sounds is their low attenuation as a result of which sounds can propagate under water for much greater distances than in air. In addition to attenuation due to the properties of the water itself, the distance of sound propagation under water is influenced by the refraction of sound, its dispersion and absorption by various inhomogeneities of the medium.

III. The Methodology For Processing Radar Signals

The application of the methodology for processing radar signals and the transfer of the principles of building systems for processing them in the field of sonar systems leads to their use to determine the coordinates of the underwater object, which is performed after summarizing the results of several measurements at different locations of the transmitting and receiving devices.

When using a multi-beam echo sounder, it is possible to obtain a full coverage of the bottom with acoustic pulses in the direction across the vessel's motion, where there is a high coating density along the tack, a low coating across. The calculation of the depth in the contact spot of a multi-beam echo sounder is complex; it can include hundreds of iterations, providing for filigree detection of underwater objects. The value of the results of the depths of the multi-beam echo sounder is higher than the number of physical rays, and makes it possible to obtain an *n*-number of results of the depth values from one contact patch.

IV. Processing Of Polymer Materials

For a multi-beam echo sounder using a satellite navigation system, the materials are processed in the following order: after performing the survey work and recording materials on a magnetic carrier, it is necessary to process them with an appropriate program. Materials are transferred on magnetic media from the computer of the measuring complex (a workstation on a ship) to a post processing computer.

During post-processing, the original data does not change, but new ones are created taking into account the introduced amendments. After each depth correction operation, a control file is created, so there is always an opportunity to control the post-processing process.

A larger source of error for a multipath echo sounder is an incorrectly measured sound velocity profile. The effect of an incorrectly introduced sound speed profile can be seen on the bottom profile (sweep) - it will have a twisted look (smile), especially on the extreme rays on a flat, even floor.

There are angular corrections for the relative orientation of the roll sensor, gyrocompass and antenna of a multi-beam echo sounder. Under ideal conditions, all three sensors must be mounted so that the directions of the three axes coincide. In reality, an emergent set of sensors is visible, where the inconsistencies are called angular corrections of the offset. The results of measuring the swinging and the course are entered for accurate results of a multi-beam echo sounder. It is necessary to remember the angular offset corrections because to measure this exactly impossible.

In the calculations, the effect of inaccurate determination of the angular displacement of the sensors along the axis of the side roll on the depth determination (with an error of 2^0) for different radiation angles of a multi-beam echo sounder.

The vessel with a multipath complex is equipped with a significant number of sensors. Where some sensor performs its task, it transfers it to a personal computer. A personal computer stores data received from devices with time stamps indicating the instant of measurement of the environment parameter. And time stamps serve as a link between data from different devices. To determine the location of a point with a depth at a certain point in time, it is necessary to know the parameters of the swinging, the course and positioning at the time of receiving the depth from the echo sounder. These measurements are not synchronized, so need perform interpolation over time.

Conclusion

The advantage of multipath echo sounders is the smaller angle of individual rays, it allows you to change the antenna tilt and get a higher resolution to the individual rays. But it also leads to the need to take into account the same parameters: onboard swinging and pitching, heading. There is also a critical parameter - the profile of the speed of sound (accounting for refraction). This leads to the use of additional sensors (motion sensor, sound velocity profile meter, gyrocompass) and to the more complex system calibration procedure. Therefore, worldwide testing of synergistic models of multi-beam surveys is offered.

Acknowledgment

We wish to thank V. Kychak, prof., I. Trotsyshyn, prof., O. Punchenko, prof. and G. Bortnyk, prof. for their insightful comments on earlier drafts.

We would also like to thank Vinnytsia National Technical University for the application of theoretical and practical research in the R & D "Development of the theory and

methodology of digital radio signal processing in real time" (Ministry of Education and Science of Ukraine, Vinnitsa National Technical University);

R & D "Development of methods for designing a fiber-optic transmission system" (Ltd "Budivelnik-3", Vinnitsa National Technical University).

REFERENCES

[1] N. Punchenko, O.Tsyra The strategy of informative redundancy of necessary measurements in the ship navigation as the independent direction in the development of a high tech park // N. Punchenko, O.Tsyra, G. Kovalova and others// IEEE 5th International Conference on Methods and Systems of Navigation and Motion Control (MSNMC): October, 16-18, 2018 Kyiv, 2018. – P. 110 – 113.

[2] Algorithms for processing hydroacoustic signals: monograph / I. V. Karabanov, A. S. Mironov. - Khabarovsk: Pacific Publishing House. state, un-that, 2018. -140 with. 1SBN 978-5-7389-2363-0

[3] N. Punchenko Information technologies: current state and prospects: monograph / G.V. Aloshin, O.O. Besonov, N.O. Punchenko et al., Under total. ed. V.S. Ponomarenko - Kharkiv: Dis Plus C LLC, 2018 - 462.