UDC 629.5.052.2:531.719.3

THE EFFECT OF INACCURACIES OF THE AUXILIARY SENSORS IN THE COURSE OF DATA PROCESSING OF MULTIBEAM SURVEY

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Abstract. *Requirements to different hydrographic surveys are much higher nowadays. They have increased the importance of the determination of all additional corrections to the data. This article is dedicated to different methods and approaches to determination of the corrections for all additional sensors for multibeam surveying systems.*

Keywords: *correction, echosounder, hydrographic survey, relief of bottom, treatment of results.*

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ВПЛИВ ПОГРІШНОСТЕЙ ДОПОМІЖНИХ ДАТЧИКІВ ПРИ ОБРОБЦІ ДАНИХ БАГАТОПРОМЕНЕВОЇ ЗЙОМКИ

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Анотація. *Підвищення вимог до проведення різноманітних робіт, пов'язаних з гідрографічними зйомками виявили проблему правильного та повного врахування додаткових поправок до виміряних різними засобами та системами параметрів. У статті представлені методи, способи та прийоми щодо отримання істинних можливостей приборів та систем, що використовуються для отримання додаткової інформації про характер руху судна та про профіль вимірюваної поверхні.*

Ключові слова*: погрішність, ехолот, гідрографічна зйомка, рельєф дна, обробка результатів.*

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ВЛИЯНИЕ ПОГРЕШНОСТЕЙ ВСПОМОГАТЕЛЬНЫХ ДАТЧИКОВ ПРИ ОБРАБОТКЕ ДАННЫХ МНОГОЛУЧЕВОЙ СЪЕМКИ

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Аннотация. *Повышение требований к проведению разнообразных работ связанных с гидрографическими съемками выявили проблему правильного и полного учета дополнительных поправок к измеряемым различными средствами и системами параметров. В статье представлены методы, способы и приемы, определяющие истинные возможности приборов и систем, которые используются для получения дополнительной информации о характере движения судна и профиля измеряемой поверхности.*

Ключевые слова*: погрешность, эхолот, гидрографическая съемка, рельеф дна, обработка результатов.*

General description of the task and its relation to the important scientific and practical tasks. Multibeam technologies are becoming more important for hydrographic surveys and for other types of surveys, for example, for the search and detection of the sunken objects, marine engineering constructions inspection, surveys of the locations of the oil and gas sea platforms and the pipelines. Main parameter to receive the reliable results of the survey is to take into account all possible corrections. This can only be achieved by exploiting methods, procedures and actions that determine true abilities of the equipment and systems used to get additional information about the vessel motion and the profile of the surface.

Analysis of the recent developments and publications dedicated to this problem solution and highlight of the unsolved parts of it. Accordingly to the S-44 Hydrographic Survey Standards by IHO, the full bottom coverage is required for the Special Order, Category 1a and 1b surveys which can only be achieved using multibeam echosounder (MBE) or a combination of the singlebeam and sidescan sonars.

Today a multibeam echosounder has permanently took its place in many hydrographic services around the Globe and in surveying companies (i.e. port authorities, oil and gas companies etc.)

From one hand a multibeam echosounder has advantages compared to more traditional singlebeam sonar such as:

1. Sweep coverage of the bottom.
2. Depending on the relief, the survey with an MBE can be more time effective than the singlebeam survey over the perpendicular planned lines.

From the other hand, it has some disadvantages such as:

1. Higher cost
2. More levels of freedom and, thus, additional sensors are necessary to measure motion, heading and sound velocity profile.
3. More complicated calibration procedures.

Main task to improve the quality of the survey is to take into account errors due to incorrect performance of the additional sensors (sound velocity profiler, gyro and MRU) and also errors due to incorrect calibration of the multibeam echosounder system. The purpose of this article is to systematize of the information from additional sensors and to estimate of the errors of the data from these sensors.

Details of the research with the justification of the scientific results are followed. Sound Velocity Artifacts. Unlike singlebeam sonar, which requires an average sound velocity in the water column for proper operation, for the multibeam sonar it is important to know the distribution of a sound velocity in the column for correct ray tracing, especially for the non-nadir beams.

By the Snell's Law, the relation between a sinus of the angle of incidence of the falling ray to a velocity should be constant at the boundary of two layers with different properties (figure1).

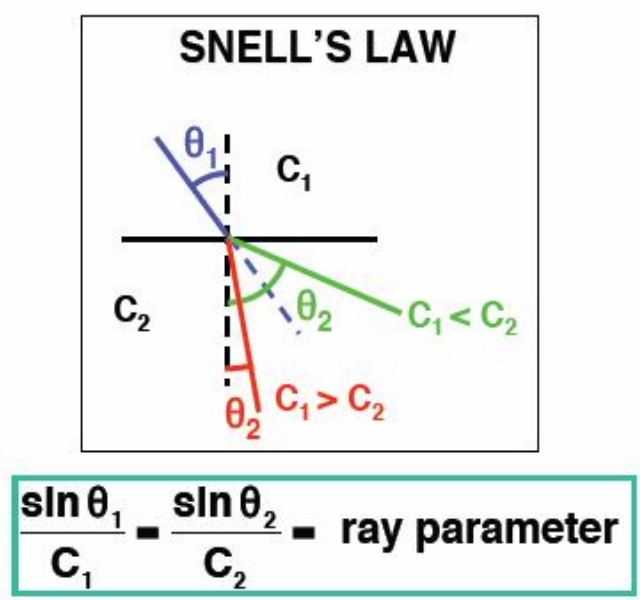

Figure 1. Sound Velocity Refraction in the water

As a result, an error in the ray tracing will lead to a banded bottom profile. Such artifact is easy to detect when looking at the cross section profile over the flat bottom. If there is a «smile» in the profile it is an evidence of sound velocity artifacts in the data (figure 2 and 3).

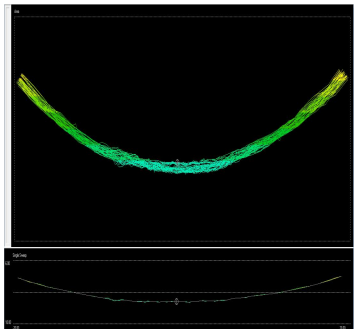

Figure 2. Increased SV

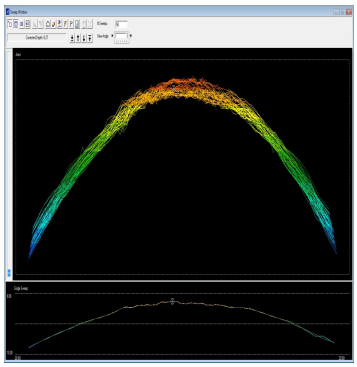

Figure 3. Decreased SV

Heave Artifacts. If there is no heave data or they are incorrect than the flat bottom will look «wavy» (figure 4).

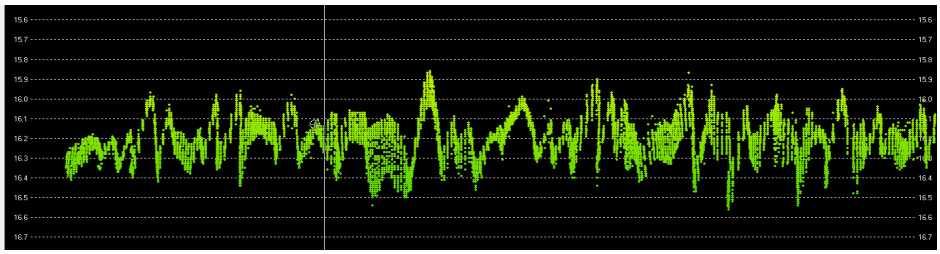

Figure 4. Along track profile with the data not corrected for heave. Profile view of the data in HYSWEEP Editor (HYPACK)

Roll Artifacts. Roll artifact is increased with the beam angle i.e. it is almost zero at the nadir area and it is maximum on outer beams (figure 5).

Roll measurement may be incorrect in two cases:

1. Roll angular misalignment between the MRU and the MBE sonar head.

As the result, the flat bottom will have some slope.

This artifact can be removed by performing the Patch Test calibration procedure. Two lines run over the flat bottom in reciprocal directions.

2. Bad roll data from MRU or no roll data at all.

Such artifact is easy to detect on a flat bottom if you see asynchronous waves on the sides of the track as shown in the figure 6.

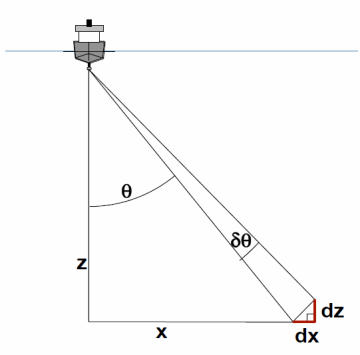

Figure 5. Roll Artifact

Latency Artifacts. There is some time delay between the moment when a GPS has found the position and the moment this data arrives to a computer that is called latency.

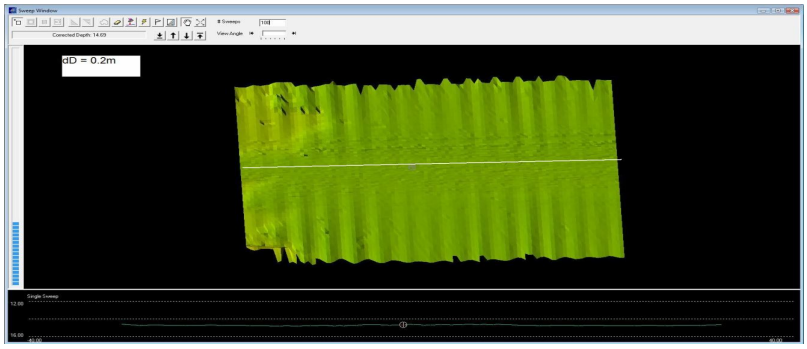

Figure 6. Roll Artifact

If there is latency in the data it can lead to a shift of the real slope. It is easy to detect if you overlay two along track profiles made across the slope in the same direction but with different speed (MBE) or in opposite directions with the same speed (SBE). Figure 7 shows the latency of 1s leads to almost 3.5m shift of the slope at a depth of 8-15 m.

The best way to determine the latency is to perform the Patch Test.

Pitch Artifact It is almost impossible to install the transducer and an MRU fully aligned along all boat reference axes. Angular offset (δφ) along the keel (i.e. pitch angle) may lead to bottom position error in both, horizontal and vertical directions (figure 8). For example, 5 degrees pitch angle can result in the vertical error equal to 0,5 % of the depth range. Since the MBE signal is spreading downwards, vertical error (dZ) is negligible compared to the horizontal one (dX).

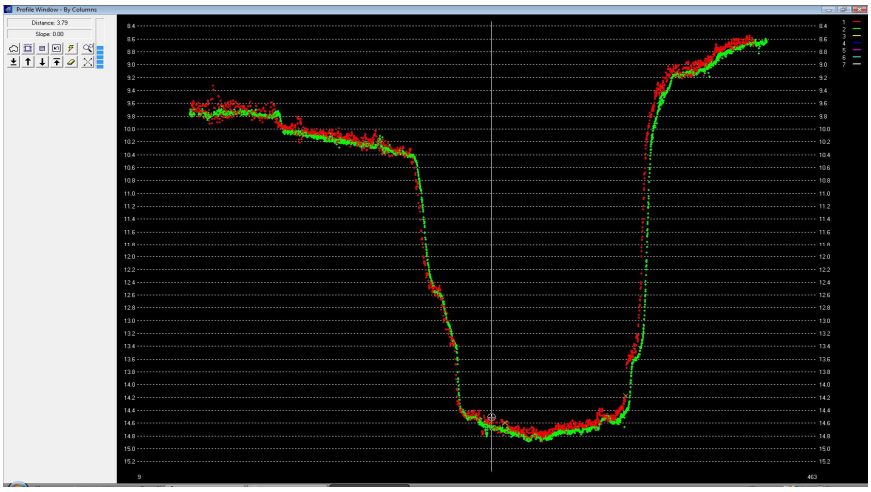

Figure 7. Profile viewof thetwo datasetts with the latency artifact along the track across the channel in HYSWEEP Editor

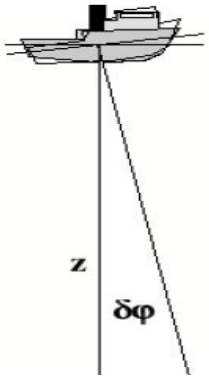

Figure 8. Pitch artifact

Pitch angle is determined by the Patch Test procedure over the slope or over an object on the bottom in the deepest part of survey area. Two runs over the same planned line at opposite directions are necessary.

During post processing of the survey data we have found out that 10 degrees pitch angle resulted in horizontal shift of 7,5 m and vertical shift of 0,05 m at 15 m depth range.

Heading Artifact. Heading artifact result in horizontal error of the bottom detected especially on the outer beams of an MBES. This error is increased with the depth range.

Such an artifact can be found because there is an angular misalignment between the transducer and the vessel frame or MRU frame.

Heading angle can be determined during the Patch Test procedure over the slope or an object on the bottom be running two lines in the same direction offset by one depth distance.

The conclusions and the prospects of the farther study. Hydrographic surveys should follow the international sets of rules and procedures from one hand and are affected by quick changes of the conditions of the relief, survey boat properties as well as by parameters and restrictions of the sensors and automatic complexes involved. All this leads to more attention paid to better estimation of the hydrographic surveys accuracy and to more parameters to determine. Therefore it is more important now to develop some automatic methods to determine artifacts from the additional sensors [3], aimed at integrated combination of the computation abilities of the computers and professional preparation of the personal.

The described problem can be solved by using systematic approach to the studies of the new patterns of the artifacts, their interactions and, as the result, to level up the performance and reliability of the surveys.

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Стаття надійшла до редакції 20.11.2018

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