EXAMINATION OF THE CO-OPERATION BETWEEN ECHOSOUNDER AND MOTION SENSOR DURING SEA TRIALS

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Sea trials with parametric echosounder SES-2000 Compact needs precise information about sounded area of the seafloor. Because of narrow beam both in horizontal and vertical surface each change of antenna position have high influence for results and analyze of measured data. Vessel has to be equipped with a special device, such as multibeam echosounder, to obtain more information about seafloor sounding which is an addition for basic measurements units. Information about bottom topography, from where sounding pulse comes, may give many useful data necessary to correct analyze by echosounder user. There are also parameters such as roll, pitch and heave, which have to be complied. These variables have an influence for shape and echo level. The last parameter analyzed in this article is a difference between vessels heading and bearing. This information comes from heading sensor and GPS receiver.

INTRODUCTION

Measurements in real conditions are very difficult due to specific conditions. It is necessary to make proper calibration not only of main elements, which were during our investigation: parametric echosounder SES-2000 compact and complementary multibeam echosounder EM-3002, but also units like: pitch, roll and heave sensor, heading unit, GPS receiver, sound velocity profiler SD 204, weather station and navigation program. Data stored on all controlling computers should be synchronized by GPS time what gives user opportunity to correlate sounding data and information coming from other sensors. Sound velocity profiler doesn't deliver data in real-time. It is necessary to update this information by making measurement at anchor. All this facts show that survey on Gdańsk Sea Bay and proper analyze of received data depend on wide spectrum of elements.

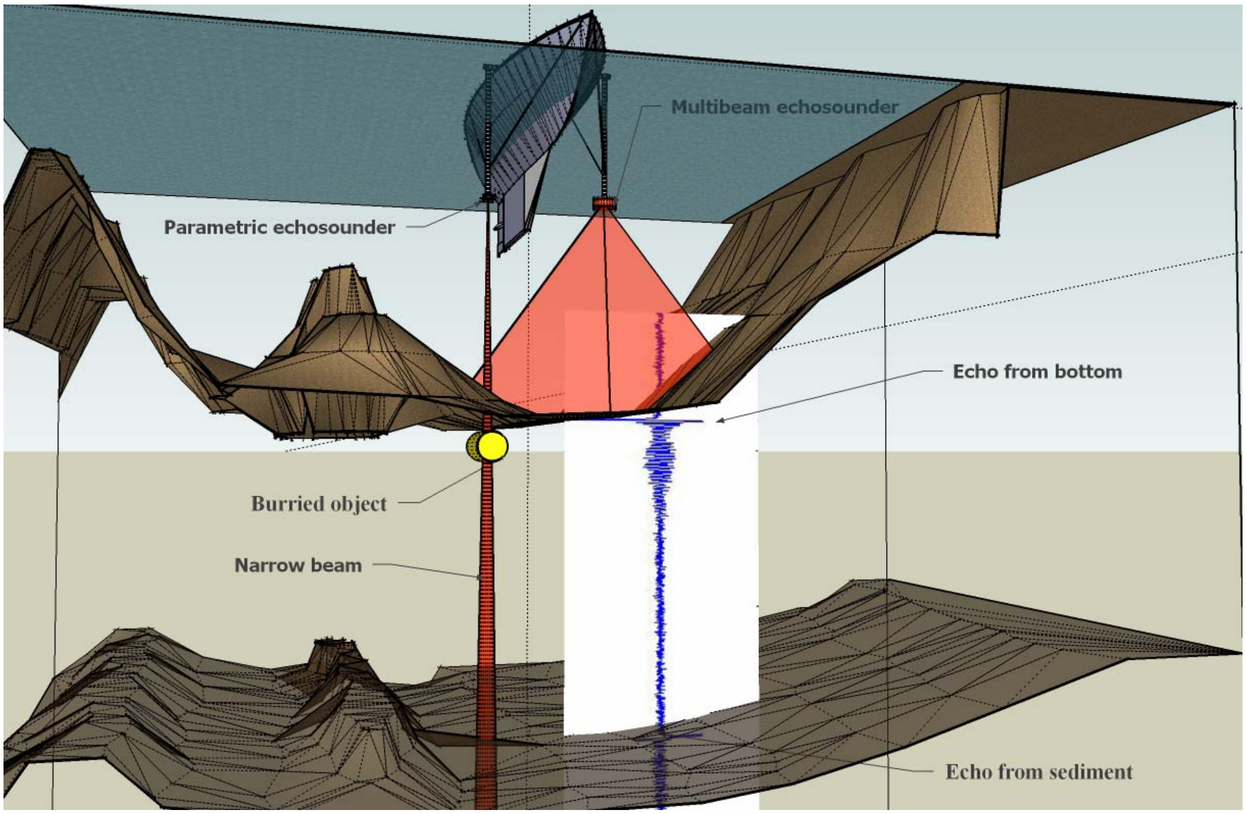

Fig.1. Sea trials with parametric and multibeam echosounder

1. MEASUREMENT VESSEL CONFIGURATION

Over the side mounts give opportunity to place parametric and multibeam echosounder antenna in the midship (this place provides proper conditions for transducers during rapid weather change) of measurement vessel Fig. 2. Transducers were 120 cm under sea surface what protects from coming out from water. Latitude and longitude was calculated in software of each device to correct offset from GPS receiver to the center of transmitting sounding pulse array. Pitch, roll and heave sensors could be mount over antennas and because of possibility to use software "Lever arm correction" units were inside cabin.

Fig.2. Measurement vessel

Navigation software store information delivered from all connected sensors and make possible investigate the same tracks with precise autopilot steering.

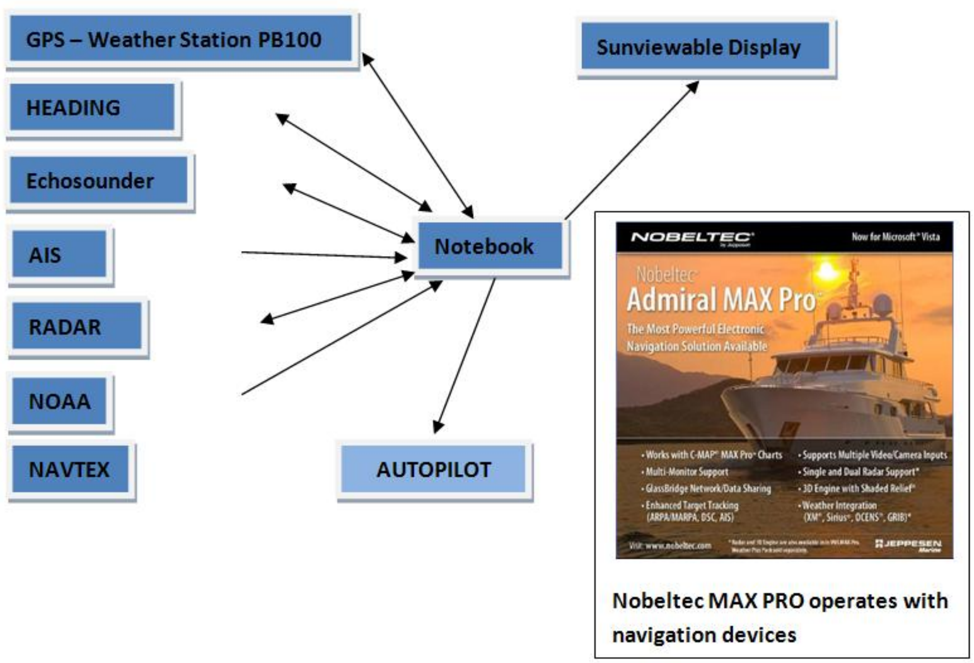

Fig.3. Configuration of navigation station

Each of echosounder is equipped in individual Kongsberg's motion sensor type MRU-Z and MRU-H.

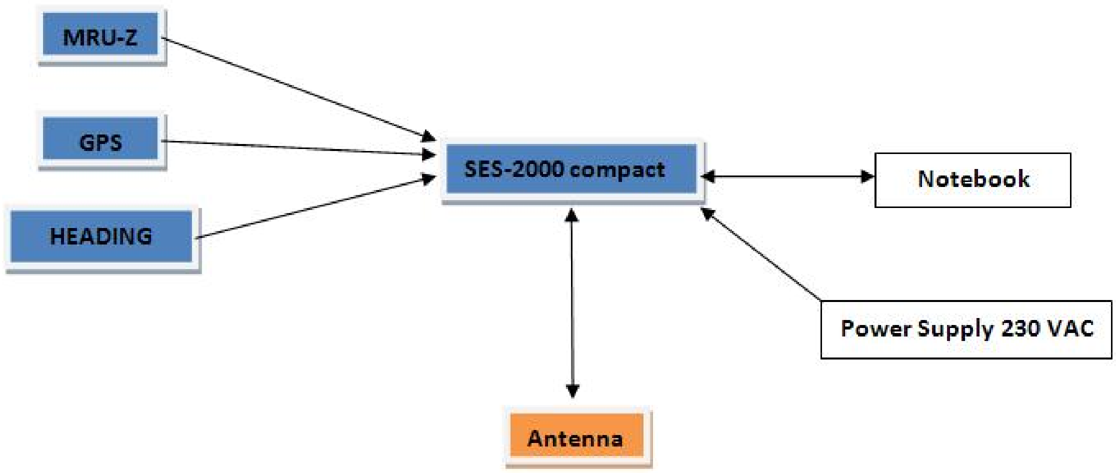

Fig.4. Configuration of parametric echosounder SES-2000 Compact

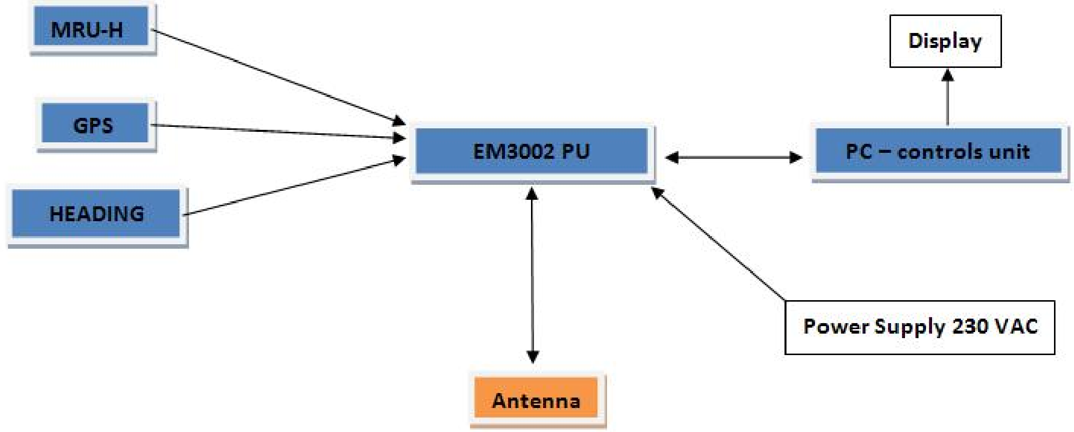

Fig.5. Configuration of multibeam echosounder

2. THE IMPACT OF PITCH, ROLL AND HEAVE ON MEASUREMENTS RESULTS

Every vessel is projected to be an instrument resort to perform different practices such as hydroacoustic investigations on smaller or bigger reservoir. The vessel movements are depending on weather conditions such as wind and waving which is a wind result. These conditions affect on drift, pitch, roll and heave. The vessel drift appears, when influence of waving, wind and sea tide direction is different of actual bearing. Drift attains the largest value for angle between direction along vessel axis and bearing, equal 90 degrees. This phenomenon may be reduced by measure these factors influence for drift scale, and in the next step after some appropriate calculations, ought to set vessel heading to finally obtain property bearing. The case, when vessel axis direction is different of bearing is the main problem in measurements performing repeatability. It’s very important, because some transects ought to sounding few times, and in each time with different echosounder sets. When every pass positions oscillate around destination line, but not to line up with it. In this case it doesn’t consider these results in reliable mean, when diversification of sea bed on few meter section may be significant, so it excludes these results in next measurement phase.

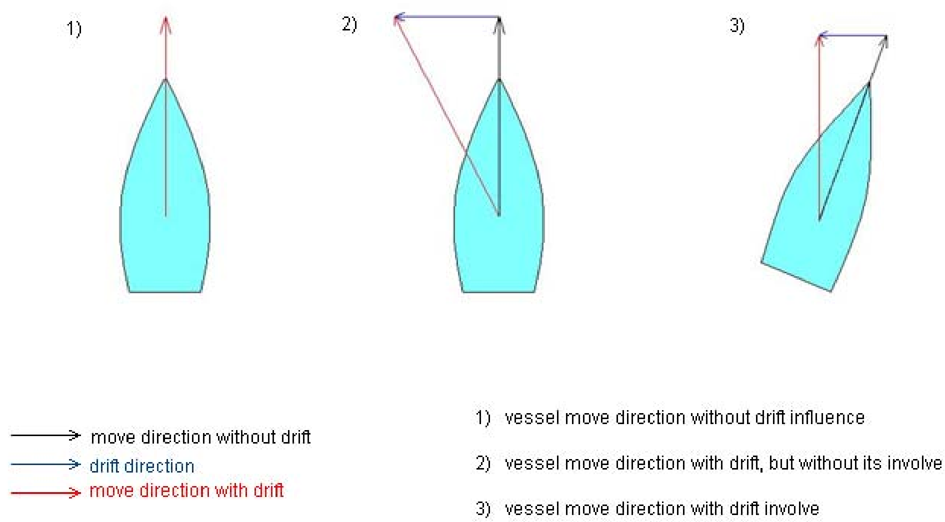

Fig.6. The drift influence on vessel movements

There are few problems connected with weather conditions. One of them is waving impact on scale of vessel roll. Standing wave propagated in orthogonal direction to vessel heading has the biggest effect on roll changes. It is directly related to moves magnitude in this plane. Pitch also results from the same conditions that roll motion. The difference is direction of wave propagation opposite to vessel heading. General geometry of bigger ships, when the relation between length and width is biggish, bridges pitch values. That why there is only applied echosounder beam cross stabilization (roll). For small value of this relation, pitch and roll are comparable. When these two effects coincide, it causes quite big ship deviation from horizontal plane. It is equivalent with antenna deviation from static location. For the parametric echosounder with quite small beam width, this deviation causes echo pulse angle from a sea bottom and subbottom sediments changing. Narrow beam width complies with big data resolution. However when it is connected with roll and pitch, the coming sound wave carries information not compliant with object features. The energy of pulse generated exactly at 90 degrees of horizontal plane decreases in time propagation. When the absorption with irregular sea bottom and antenna motion occurs in the same time during pulse transmission that received pulse parameters are inconsistent with underwater object physical features. This is a significant impediment in further analyze and object or subbottom sediments classification probes.

Sea waving without its direction distinction also affects on heave values. The heave variable means temporary difference of point location in vertical line. Along with this value increase, the distance from an antenna and sea bottom surface is growing. This causes longer time propagation of sound pulse in both directions and also causes increased depth value on the echogram. Flat sea bottom is waved in visible means without this phenomena compensation. In sea bottom structure research with parametric echosounder, which beam can penetrate the sea bed, changing of vessel location in vertical direction causes constant distance amend between next layers. In practice, when the sound wave penetrates quite deeply in sea bottom, there is a steady waving along each of layers, which conforms temporary changing value of position in vertical shown in displays below (Fig. 7, Fig. 8).

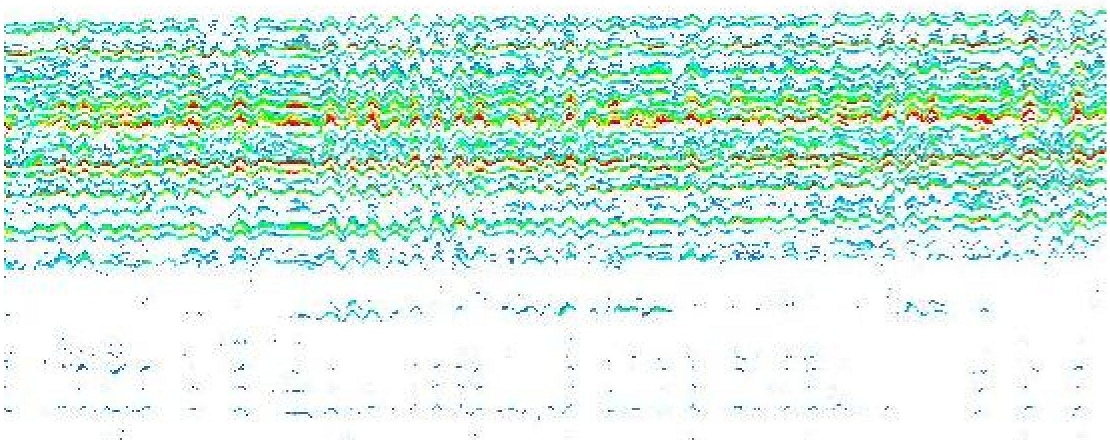

Fig.7. Sea bottom sediments without heave compensation

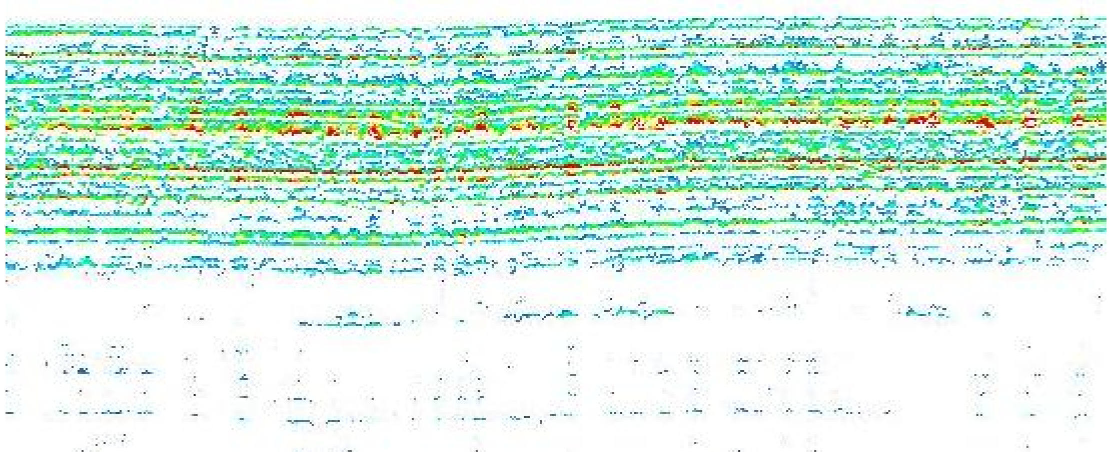

Fig.8. Sea bottom sediments with heave compensation

Pitch, roll and heave aren't correlated along with themselves. There is no direct relation between their temporary values. The main reason of this is continuous impact of external conditions. Values changes in time (Fig. 9) represent conditions, which were in relevant moment at sea. Red line in particular charts is an average deflection (for heave) or average angle change (for pitch and roll) from previous probes as from value for a time equal zero.

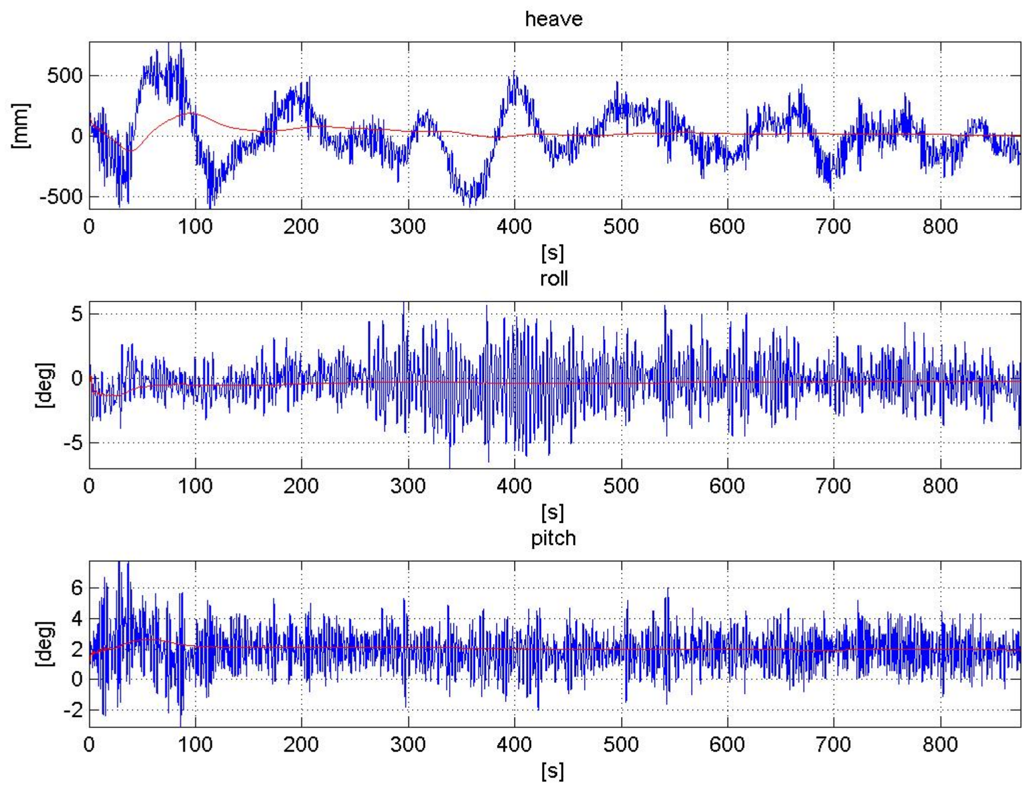

Fig.9. Heave, roll and pitch relations of time in selected transect

3. COMPARISON OF MOTION SENSOR UNIT (MRU) INTEGRATION WITH PARAMETRIC ECHOSOUNDER SES-2000 COMPACT AND SES-2000 STANDARD

Both of these devices are Innomar products. There are parametric echosounders basing on nonlinear water properties. This comparison concentrates on various implementation MRU sensor with each of describing echosounders. In both cases the control-compensation unit is electronic sensor Seatex MRU-Z, whose working is based on 3-axis gyroscope and location changing sensor in all of planes.

- Echosounder SES-2000 Compact with MRU-Z sensor was tested in-situ on light boat, which is susceptible on increased sea state influence. Seatex MRU-Z is integrated with the echosounder by serial communication in RS-232C standard. The echosounder control unit has in front panel serial connection to transmitting necessary information, which is receiving by MRU. This motion sensor has to be appropriately configurated by MRC software.

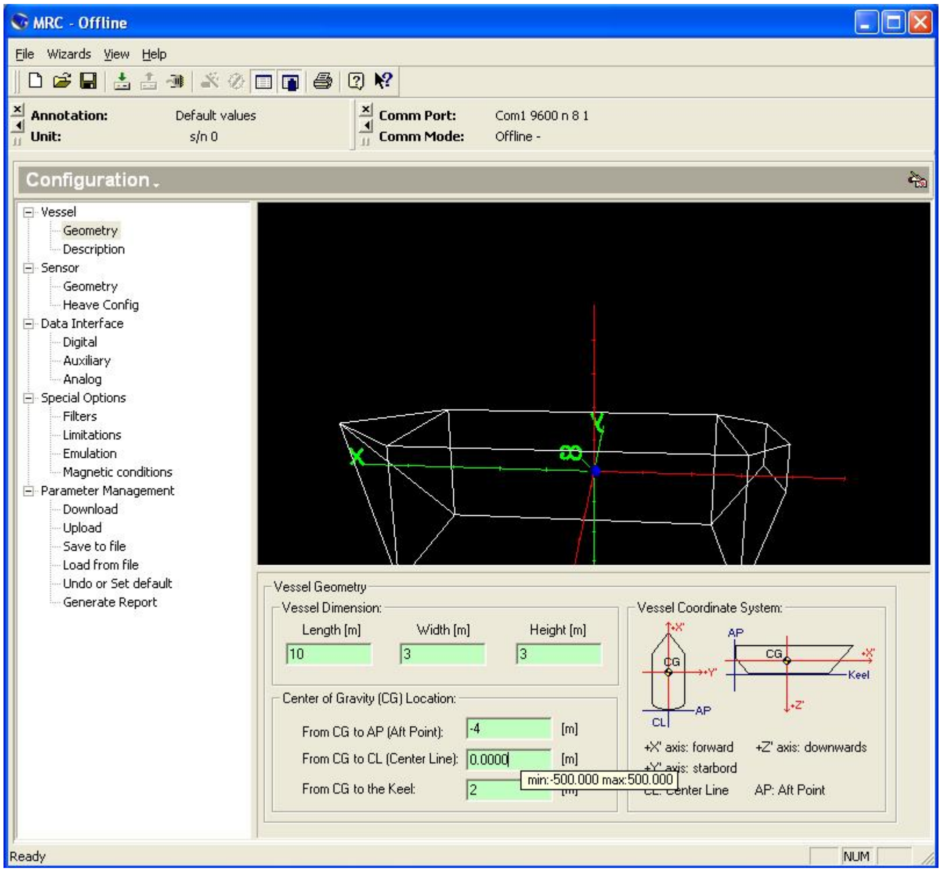

Fig.10. Configuration window of MRC software

The most important setting parameters are motion sensor particular static position against center of gravity and place of antenna installation. Imprecise measure of these values directly causes wrong MRU compensation. There also have to be confirmed the communication parameters, such as protocol and baud rate. In case of too small baud rate setting, the compensation may be not complete. Devices co-operate property, echosounder control unit indicates full compatibility communication, in turn in significant moves such as roll, and pitch or heave, there is insufficient correction of depth value, which is dependent on temporary deflection from static location. The protocol used in this communication, called EM-3000 is shown below:

SF HB RR RR PP PP hh hh HH HH

Where: SF – status; HB – header; RR – roll; PP – pitch; hh – heave; HH – heading

Parameters of serial communication:

Baud rate: 19200 b/s; Data bits: 8; Stop bit: 1; Parity: None

Pitch, roll and heave are sending continuously to echosounder. During data recording, these values are also recorded in .ses file and repeated cyclically after each sending pulse.

While completely data from MRU are sending to echosounder, they are only displayed in software and there is only one various provided in calculations, namely heave. Compensation is resolved by heave value subtraction from temporary depth value. This operation is performed after each recorded data series. This kind of elimination the influence of unwanted vessel movements is not the best method, because the compensation is performed after measurement and it isn't conclusive in support only of heave values.

- Echosounder SES-2000 Standard with MRU-Z was only used during laboratory measurements. MRU sensor was configurated such as with Compact echosounder. Communication based on the same protocol and also the same transmitting data. The significant difference is possibility to form beam by beamformer from -16° to +16° in cross plane to vessel heading. It is the solution of roll compensation. In this device also is taken into account a heave parameter. During investigations on water tank, which length is equal 30 m and width is equal 3 m and 1,8 m depth, the antenna was installed in half basin depth in the same direction as his axis. MRU sensor along with precise base, which was used to determine angle deflection from vertical, gave the possibility of deflection controlling and investigation of angle accuracy balancing. Beam directivity characteristic was measured at 6 m from an antenna by ITC 10890 hydrophone with moving arm (Fig. 11) in perpendicular plane to basin axis and beam transmitting. The measure relied on investigation of antenna directivity characteristic for a MRU static location. In the second stage there was made a MRU pitch angle change to vertical axis and next investigation of characteristic. After this measure series in laboratory terms, it was affirmed that beam steering was resolved in agrees with theoretical preliminaries. Additional compensation in SES-2000 Standard should correcting quite big roll in significant means.

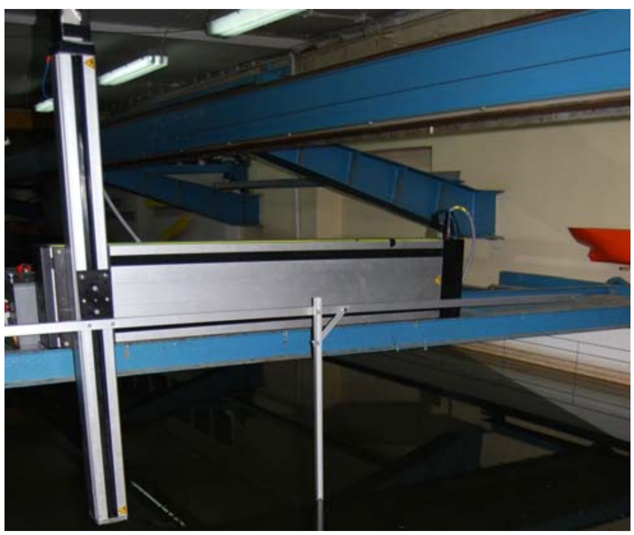

Fig.11. Precision arm with a hydrophone to directivity characteristic measuring

4. CONCLUSIONS

Every measurement, not only in hydroacoustic domain, is saddled with smaller or bigger fault. In purpose of obtain the greatest accuracy conducted investigations, in first case it has to reach environment identification and its impact for deviations size for a particular physical parameters. The effected measurements, whose are described in this article and their results depend on all used units specification, such as MRU sensor and kind of implementation data from it. It’s important, that the investigations have to effect in as good as possible sea conditions, because it results in definitely smaller deviations of final results.

ACKNOWLEDGMENTS

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