SPECIAL FORMS OF ECHO VISUAL REPRESENTATION IN AN AHEAD LOOKING SONAR

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The paper discusses ways to organise visual representation in a multi-beam ahead looking sonars whose function is to detect objects on the bottom and in pelagic zones. Forms of visual representation are shown and illustrated on the basic screen (panoramic representation and setting, alarms) and on the auxiliary screen (type A, B and special). Special forms of visual representation are mainly used in detecting objects in difficult hydrological conditions and when classifying objects. Several types of visual representations are shown, including a "historical" data example, multiplied type A representation in multiple beams and two types of quasi-spatial displays.

INTRODUCTION

The effectiveness of sounding is largely dependent on how well the sonar's visual representation functions are performed. The advantages of advanced electronic signal processing can be easily lost, if not properly displayed to enable the operator to better understand what is usually a complex underwater scenario. The likelihood of it happening increases because the operator has not only to watch the screens but also communicate with other naval systems and optimise sonar settings. It is probably safe to say that a user friendly and readable display is perhaps the most critical factor in assessing a system's quality.

With the advancement of electronic technologies and hardware in particular, with more and more powerful computers and better operating systems, more readable and effective displays can be developed.

Every few years completely new ways to provide visual representation open up. We recently presented the visual representation in a modern passive sonar developed by our team [1]. The previous visual representation [2], [3] in an active sonar was based on computers with clock frequency bellow 100 megahertz and, for many reasons, on the DOS operating system. With computers now ten times more powerful, we can use flexible, user friendly and commonly known Windows, and introduce new ways of visual representation in sonars.

The visual representation forms below were used in an ahead looking sonar designed to detect objects on the bottom and in pelagic zones. The sonar generates multiple beams simultaneously in the so called azimuth section (with beamforming on the receiving end). In the elevation section it can tilt the bend mechanically only.

1. OVERALL ORGANISATION OF VISUAL REPRESENTATION

Typically, the more advanced sonars, in particular military ones, use at least two display monitors [1].

The first screen, treated as basic, has a natural panoramic view of the space being scanned, the pictograms and values of settings keyed in by the operator plus the basic information about the status of the particular parts of the sonar, its communication with external systems and alarms in case of problems. In the lower part of the screen, you can view special windows that facilitate the process of object classification once detected. Figure 1 shows an example of the screen. The windows arrangement of the display allows the user to change the form of the display.

On the left-hand side of the second, auxiliary screen are a B type representation (with linear angle scale) and A type representation (the oscillograms of signal envelope from a selected beam, with electronic magnifier). The right-hand side upper window shows the target detection conditions that follow from a measurement taken of the range distribution of sound velocity. From the left-hand side bottom window, you can select one of the special forms of visual representation. Figure 2 shows an example of the screen. The example is of a magnified fragment of B type visual representation – a regular "electronic magnifier" showing one third of the sonar's beams and a selected fragment of the range.

2. SPECIAL FORMS OF VISUAL REPRESENTATION

Special forms of visual representation are mainly used for the detection of targets under very difficult hydrological conditions and for the classification of an object once detected. In classifying an object, the idea is to determine the object's target strength and whether it is on the bottom or floating.

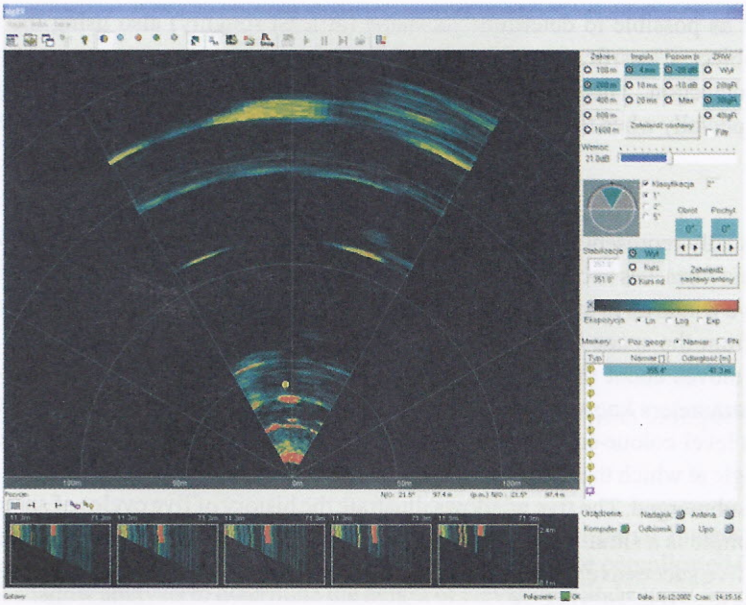

Fig. 1. Example of the sonar's basic visual representation

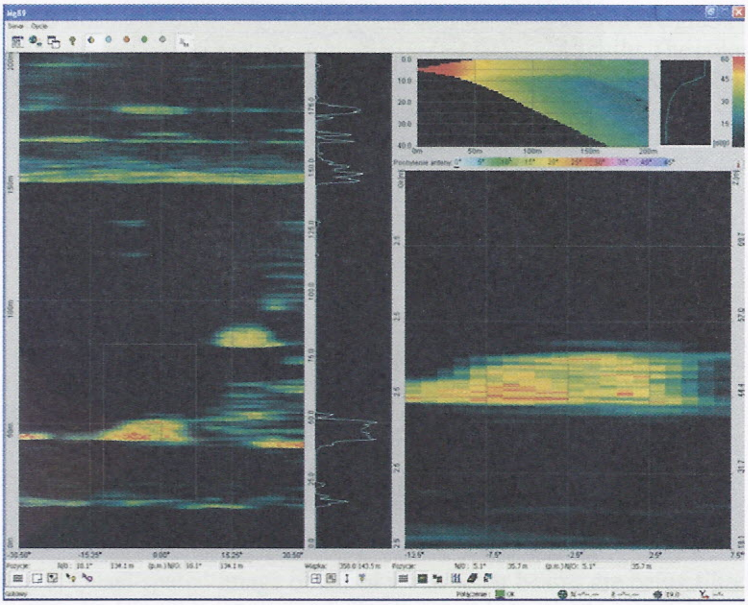

Fig. 2. Example of the sonar's auxiliary visual representation

Military sonars are used to determine whether the objects found are ground mines, moored mines or mine-like objects. More complex classification sonars use a separate high-frequency (i.e. high resolution with little range) multiple-beam transmitting and receiving tract (in practical terms, another sonar). It is put into operation when placed as close to the object as possible to determine its shape (at least roughly) also using the shadow image behind the object. Classification (formally understood as parameter estimation) is more difficult than object detection. Therefore, it is important to assist the operator in making classification decisions, especially when the sonar does not come with visual representation functions.

3. HISTOGRAMS

To visually represent the findings, several different forms were used to aid the operator. The idea of the first form was to compare the images of echoes from successive transmissions (historical data). The five windows in the lower row in Fig. 1 give an example of that. The windows contain five echograms from the space before and behind the marker. The marker is given in the panoramic display and moves about the screen following the marked object detected (following the ship's movement parameters known from the on-board navigation system). Each of the windows shows the echo (its level colour-coded) from one sonar beam as the antenna gradually tilts every 5o to check the angle at which the signal is maximal. By doing this, we can determine the depth at which the object is submerged. The five windows illustrate the history of five cycles of antenna movement. Another example is a simultaneous B type display in the right-hand side window of the auxiliary screen from five successive recent transmissions from a fragment of interest to us, as marked in the left-hand side type B image (Fig.3).

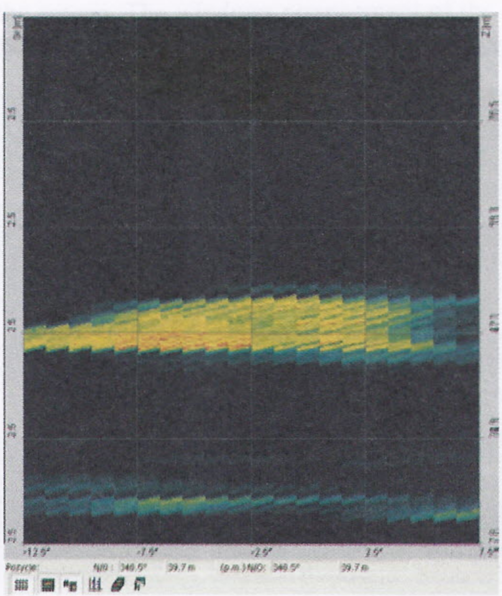

Fig 3. Type B display of a selected fragment with the "history" of the last five echo transmissions

3. MULTIPLICATION OF TYPE A IMAGES

The operator can be further assisted by simultaneously viewing type A images (signal envelopes) in multiple beams from a marked fragment of the B type image (Fig. 4).

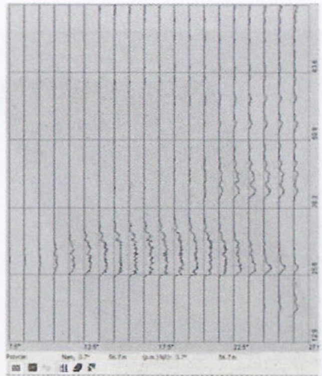

Fig. 4. Simultaneous representation of echo signal envelopes from multiple beams

4. QUASI-SPATIAL EXPOSITIONS

The remaining methods use quasi-spatial exposition. Truly spatial images can only be achieved for bottom maps made using lateral sounding, which is quite complicated (involving the use of acoustic shadow analysis to determine the height of elevations) and cannot be used on-line as a result.

In the visual representation in question, quasi-spatial representation is achieved by creating an image on type B image of a fragment of the water as the sonar's beams are gradually tilted. The beams are shown in a perspective projection while the tilt is shown naturally. The colours are used to illustrate the averaged value of signal envelopes in the beams in ten projections. The effects are shown in Figure 5.

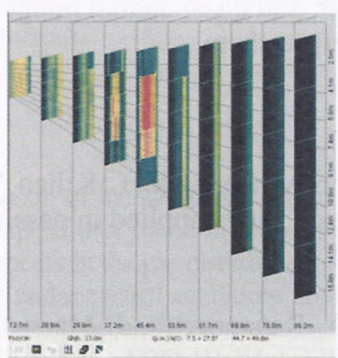

Fig. 5. Quasi-spatial image obtained when sonar beams are being tilted

Figure 6 shows the second method of how a selected fragment of the water can be represented quasi-spatially. It shows the echoes in the beams. The echo amplitude is determined using both the horizontal dimension of its image and colour. The image serves as an actual visual representation only for bottom observations. If the echo comes from a pelagic zone, all the image tells us is that it involves a horizontally expanding object with specific beams showing the highest target strength. No conclusions can be drawn about its elevation dimension, until the procedure of changing the beam tilt is completed.

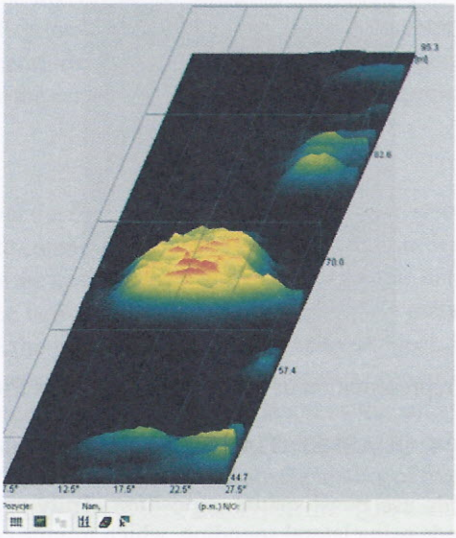

Fig. 6. Quasi-spatial representation in perspective

5. SUMMARY

The above special forms of sonar displays greatly facilitate the operator in making detection decisions leading to a possible classification of underwater objects. To use them however, and quasi-spatial images in particular, the operator must be trained in how to interpret them.

REFERENCES

1. A. Raganowicz, R. Salamon, M. Rudnicki, L. Kilian, Visual representation of the effects of spatial and frequency filters applied in passive sonars, Hydroacoustics, Vol. 4, 213-216, Gdynia 2001.

2. L. Kilian, R. Salamon, A. Raganowicz, J. Marszal, Visual representation in a multi-beam sonar, Proceedings XLIII OSA, Vol. 1, 347-352, Gliwice – Ustroñ 1996.

3. L. Kilian, J. Marszal, A. Raganowicz, R. Salamon, The organisation of the visual representation of sounding, the settings and auxiliary functions in modernised underwater acoustics stations, Proceedings VI Symposium of Military Maritime Technology, Vol. 2, 89-96, Gdynia 1997.