FORMS OF VISUAL REPRESENTATION IN HELICOPTER ON-BOARD HYDROACOUSTIC DEVICES FOR PURPOSES OF OBJECT IDENTIFICATION

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The article presents the practical aspects of a modernisation effort involving two on-board systems in Navy helicopters used for detecting and anti-submarine warfare, i.e. a sonobuoy-based system and an on-board sonar. The advantages of using digital signal processing in both systems are discussed as well as the advantages of advanced methods for visual representation of the noise picked up and the results of sounding. A description is given of the display systems before and after the modernisation.

INTRODUCTION

The progress of electronic and digital technologies has made it possible to equip aircraft and helicopters with a number of new systems. Thanks to the recent advancements, the usual difficulties in designing aircraft equipment, including hydroacoustic equipment, i.e. constraints of space, weight or impact resistance could be overcome.

The use of modern technologies and complex computational algorithms in underwater acoustics has greatly improved the detection of underwater objects, including that of modernised sonars.

On-board hydroacoustic equipment is operated by the flying personnel who are trained navigators. These specialists cannot be selected for their auditory predisposition or musical talents which could be made use of in traditional listening in for hydroacoustic signals. Given the noise level in the helicopter's cockpit, using hearing to verify contact with an underwater object would prove very difficult even for the best of operators. Special headphones or headsets are not very helpful, either. Consequently, there was a need for new methods to support classification once contact is established.

Visual representation of digitally processed signals was found quite effective. The use of colours in images of the spectrum of a detected object made it possible to discern signal profiles from the interferences in the hydroacoustic tract, allowing object classification and identification.

The use of the auditory method in detecting and classifying underwater objects proved of little effect. This had a negative impact on the quality of training for operators of on-board hydroacoustic equipment. The introduction of modern digital technology to hydroacoustic signal representation in diagrams, both flat and quasi-spatial, seems very effective.

The objective of the article is to compare the effects of images before and after the modernisation of two detection systems on anti-submarine warfare helicopters. The first system uses signals from sonobuoys placed in varying configurations across the area being searched, whereas the second is an omnidirectional sonar with a retractable antenna, operating both in passive and active modes.

1. SYSTEM FOR SONOBUOY SIGNALS TRANSMISSION

Prior to the modernisation, A-100 type devices would pick up a signal when the sonobuoy was activated by noise generated by an object. A control lamp whose number indicated the particular sonobuoy would then light up (Fig. 1). When several sonobuoys were activated, it was up to the operator to analyse the acoustic signals by listening (under difficult conditions, as mentioned before) and classify them following his subjective judgement of signal strength and type. By means of this somewhat primitive selection, the location of the submarine could be identified roughly so that the helicopter could then hover over it and submerge the sonar's antenna OKA-2 to get a precise location of the submarine. Signal misidentification and following that hovering over a wrongly selected location could lead to the submarine realising it was being observed by helicopters further leading to a camouflage decision by the ship's commander. It is only obvious that submarines have the ability to identify a hovering helicopter and the operation of a hydroacoustic antenna being lowered.

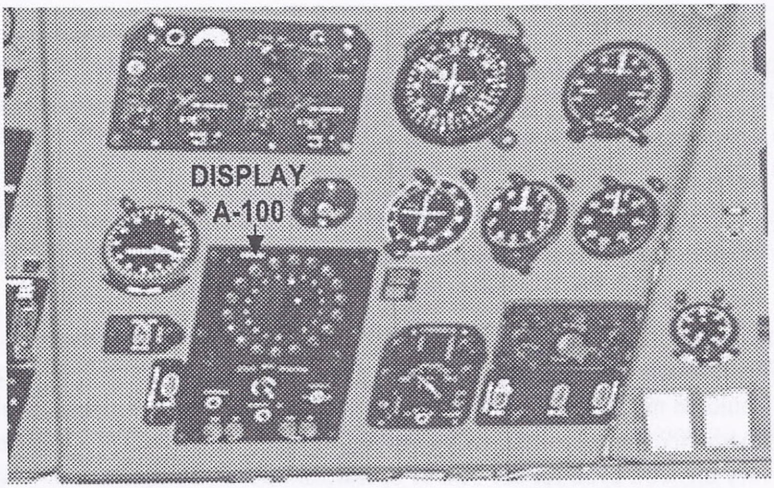

Fig. 1. The display of the sonobuoys based system prior to modernisation

Fig. 2 shows an example of a display following modernisation. More about the analysis and exposition of sonobuoy signals is given in [1]. In short – the screen shows histograms of the results of spectral analysis of signals received by each (indicated by a number) sonobuoy. The amplitudes of spectral lines are colour coded with the scale depicted in the left-hand side upper screen. If the window of one or several sonobuoys shows a similar spectrum that has a similar distribution over an extended period, the source of the signal has probably been detected, e.g. that of a submarine. The example shows that close to sonobuoy 7 is a source of a low-frequency signal, i.e. most probably a submarine, whereas the source of a broadband signal (e.g. a ship) is moving away from sonobuoy 3 and 4.

Thanks to the modernisation, the acoustic signal is displayed in a way that helps classify the contact using objective criteria. The end result is an effective passive detection and the ability to keep track of the movements of the submarine. Because submarine generated signals are correctly identified almost without fail, the operator of the system can select the best location for submerging the sonar's antenna, determine the parameters of the target's movement and process the data for attack.

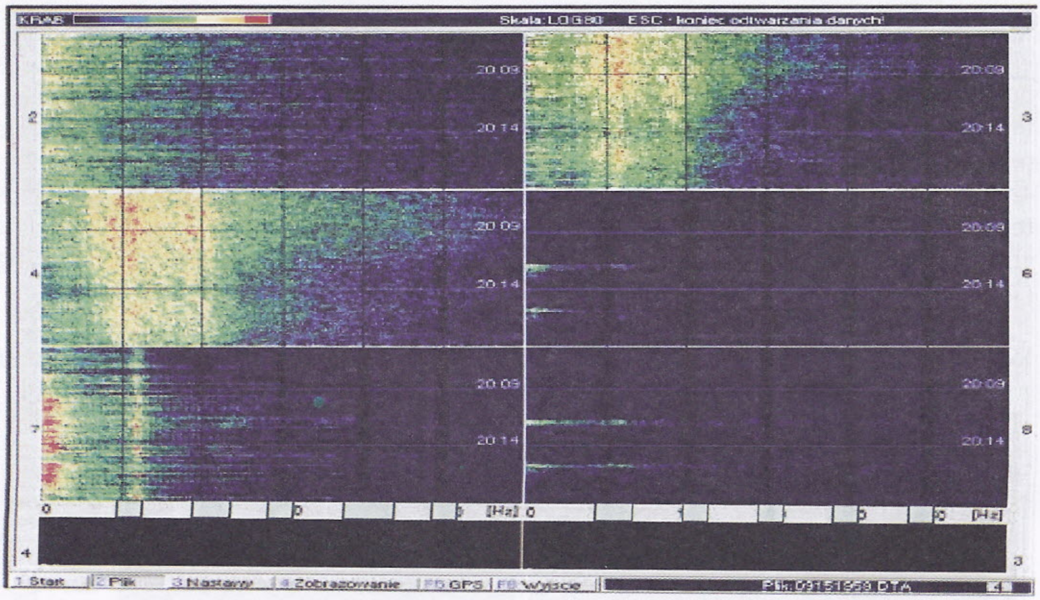

Fig. 2 shows an example of a display following modernisation. More about the analysis and

2. THE DIPPING SONAR

Prior to the modernisation, for visual representation helicopter on-board sonars used a cathode-ray oscilloscope with circular time base in active mode or marked antenna direction in passive mode. In both modes headphones were used to aid detection performance.

Figure 3 shows visual representation in active mode. On the right-hand side of display 'a' and in the lower part of display 'b' you can see spot deflections, evidence of echo signals.

a b

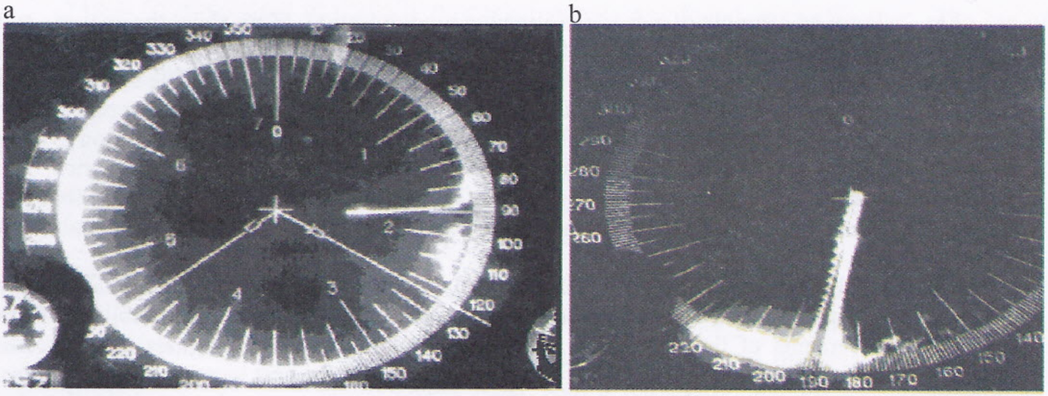

Fig. 3. On-board sonar display prior to modernisation (active mode)

Following the modernisation, both signal processing in the two modes as well as the form of sounding signals and displays could be greatly enhanced.

The upgrade of the passive mode involved lowering the listening in band (to a range where the level of submarine noise is the highest), maintaining the directivity of reception, introducing spectral analysis of signals picked up, histograms of spectra and panoramic presentation for determining signal source bearings. An example of a display is given in Fig. 4. You will find more about how the display is organised in [2]. In short - from the histograms the operator selects a sector of a spectrum, following which, the spectral lines seen as dots create a set on the panoramic view with the set matching the direction of a source bearing (195_{o} in the example).

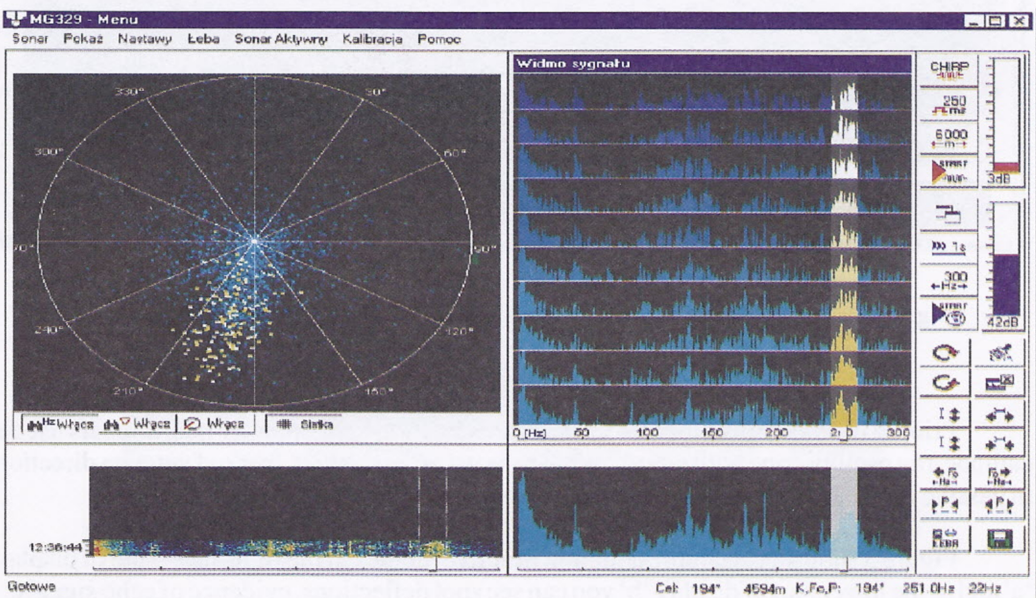

Fig. 4. Example of an on-board sonar display in passive mode after modernisation

In active mode the improvements involved the introduction of chirp sounding pulses and matched reception. By reducing the level of surface reverberations, the sonar's detection range could be significantly increased. The display uses a real panorama with colour target strength exposition and echo envelope (type A display) and electronic magnifier (zoom function).

By introducing communications with the on-board command system which provides navigation data and transmits target information, both systems can automatically visually represent the current tactical situation, i.e. the movement of a detected object. Figure 5 gives an example of the display and how it represents the route of the target. This has significantly sped up and improved the process of communications helicopter to ship and helicopter to helicopter.

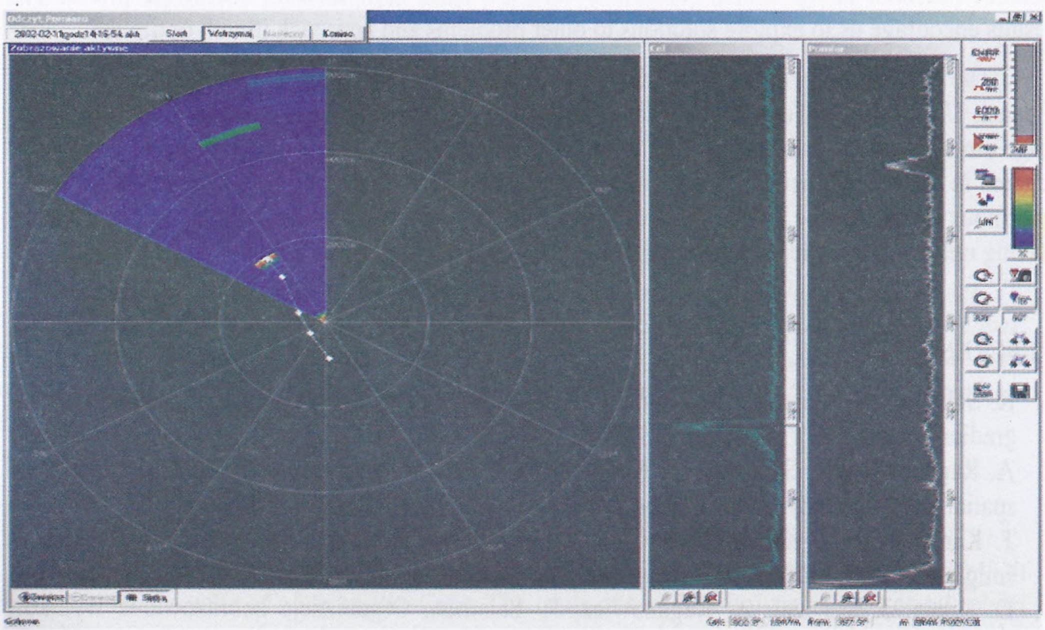

Fig. 5. Example of an on-board sonar display in active mode after modernisation

3. CONCLUSION

New ergonomic forms of graphic representation of received and digitally processed hydroacoustic signals combined with listening in have improved the performance and effectiveness of underwater detection even of inexperienced on-board operators. The ability to view the spectrum of acoustic signals and the histograms makes detection a success almost without fail. Training of on-board operators could be simplified as well.

The synthetic representation of a submarine's acoustic spectrum, previously processed, occurs almost in real time and is aided with saved histograms of previous signals. Thanks to this, the target can be better followed and the signals received can be precisely registered. Once saved, the acoustic spectra provide a very valuable tool for database building to aid detailed analyses of the signals in laboratories. Consequently, acoustic profiles of underwater objects can be developed and used to identify submarines as they are detected.

What is especially interesting in how on-board systems are built today is that the hardware and microprocessors are unified making future additions easy. The use of universal electronic filters and processor boards may lead to major cost reductions. As mentioned before, the flying school does not select navigators for their skills to operate on-board hydroacoustic equipment which is all the more reason to ensure that new equipment is user friendly and uses modern technologies to aid visual representation. The modernised on-board sonar and sonobuoy system for receiving signals are good examples of that.

By modernising the helicopter hydroacoustic system, we could significantly improve the defence potential of the Polish Navy at a very low cost, compared to worldwide prices. The results encourage us to explore solutions to other problems and approach it with optimism.

The task the Navy gave to the designers and engineers from the Department of Acoustics, Gdansk University of Technology, was a tall order. The governments of many countries spend huge amounts every year to both build and detect submarines. The achievements of worldwide leaders in underwater acoustics cannot be underestimated. There is no doubt, however, as to the enormous success of the DA TUG researchers who were able to catch up with the world's leaders having only their excellent knowledge, zeal and a small budget as back-up.

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