

## **MODERNIZATION OF ASW SONAR SQS-56 AT GDANSK UNIVERSITY OF TECHNOLOGY**

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*The fast development of electronic technology and digital signal processing methods makes electronic devices, including sonar systems ones, obsolete very quickly. On the other hand the ships mechanical components including mechanical parts of sonars are operational for a few dozens of years. It makes good opportunity to modernize these devices by using modern electronic devices and new digital signal processing methods with application of existing antenna and mechanical systems. The paper presents the modernization of ASW sonar SQS-56 on the Polish frigate ORP "Kościusko". The aim of modernization, the new parameters of the sonar and block diagram after modernization are presented.*

### INTRODUCTION

The majority of Polish Navy vessels were built between 1970 and 1990 and equipped with Soviet or Polish made sonar systems. In the end of XX century the Polish Navy added to its fleet two Oliver Hazard Perry frigates with ASW passive towed array sonar SQR-19 and keel ASW sonar SQS-56. A team of researchers from the Department of Marine Electronics Systems of the Gdansk University of Technology obtained several contracts from Polish Navy for modernizing a number of sonars. Their work aimed to achieve a significant improvement of the parameters of sonars at a low cost. This objective could be realized, if the existing expensive mechanical transducer arrays were kept, together with the stabilization systems. In addition, new electronic blocks have to be designed, using modern technologies and digital methods of signal processing. This approach was used to modernize dipping sonars OKA-2 designed for anti-submarine warfare helicopters, mine countermeasures sonars MG-89, ASW

sonar MG-322 as well as for towed array sonar SQR-19 [1, 2]. At present, work is under way on modernizing ASW keel sonar SQS-56. The work will be finished after sea testing on June 2010.

## 1. MODERNIZATION AIM

The SQS-56 is a keel mounted sonar with a cylindrical antenna. It was installed on Oliver Hazard Perry frigates, dating back to the seventies and eighties of the last century. The main reason for the modernization was to upgrade the sonar's functional design and software to modern technology standards without changing the existing cylindrical antenna and mechanical elements. The modernization was expected to improve the tactical and technical parameters of SQS-56, its operation and reliability and to reduce the size of the components by using modern technology to improve the equipment and software.

These objectives has been realized by:

- In sonar equipment space:
  - Modernization of transmitter control circuits with application of DDS AD9954 devices and microprocessor MSP430F5438 (the power amplifiers, impedance matching and cylindrical antenna are left original).
  - Modernization of receiver with application of new analog to digital conversion and LVDS data transmission from the sonar equipment space to the sonar control space (the input analog receivers are only slightly changed).
  - The application of synchro to digital and digital to synchro converters for coupling with existing combat system.
  - Other existing units from sonar equipment room are removed.
- In sonar control space all units are completely newly designed:
  - The LVDS data receiver.
  - Digital Signal Processor based on TMS 320C6713v300MHz devices (20 boards with 2 TMS each) with Compact PCI bus and main control computer KONTRON CP605.
  - Implementation of newly elaborated DSP algorithms [3-9].
  - 4 visualization and user interface computers GE Fanuc VR9.
  - Two operator consoles with two LCD 17" monitor each.

## 2. SONAR PARAMETERS AFTER MODERNIZATION

The application of new sonar structure and new digital signal processing made it possible to improve sonar performances. The main technical parameters of the sonar SQS-56 after modernization are presented in the table below.

No	Parameter	Value
1.	Transducer array	Cylindrical, 36 staves with 8 elements each Ø = 122 mm, h = 84mm
2.	Sounding pulses type	CW LFM HFM CW + FM

No	Parameter	Value
3.	Operating frequencies	6,7 kHz; 7,5 kHz; 8,4 kHz.
4.	Frequency deviation for FM pulses	400 Hz, 800Hz – for each of operating frequencies; 1600 Hz – only for 7,5 kHz
5.	Output power (sum of all channels)	36 kW
6.	Source level dB re 1m, 1 $\mu$ Pa	$\geq 215$ dB
7.	Transmitting horizontal beamwidth (-3dB)	From 90° to 360° with 10° step
8.	Transmitting vertical beamwidth (-3dB)	12°, 24°
9.	Receiving bandwidth for active search	6,2 kHz – 8,9 kHz
10.	Receiving bandwidth for passive search	3 kHz – 10 kHz
11.	Number of transmitting and receiving channels	36
12.	Number of output beams	72
13.	Receiving horizontal beamwidth (-3dB)	14° $\pm$ 1° at 7,5 kHz
14.	Receiving vertical beamwidth (-3dB)	12° $\pm$ 2,5° at 7,5 kHz
15.	Observation sector	From 90° to 360° with 10° step
16.	Distance ranges	0.5; 1; 2; 4; 8; 16; 32 km (0.5; 1 km for Obstacle Avoidance)
17.	Sounding pulses duration	5, 10, 25, 50, 100, 200, 400, 800, 1600 ms (5, 10 ms for Obstacle Avoidance)
18.	Analog to digital conversion	36 channels, 16 bit, second order sampling
19.	Beamforming type	Digital in frequency domain with second order sampling
20.	Post beamforming filtering	Matched digital in time domain, max pulse compression 2560, Doppler analysis
21.	Precise bearing algorithm	Digital mono-pulse method
22.	Passive signal processing	Wideband beamforming in frequency domain, FFT
23.	System function	ASW surveillance – active, passive mode; Passive Torpedo Warning; Obstacle Avoidance; Sound Velocity Profiler analysis; On-Board Trainer;
24.	Displays type	4 LCD monitors with optional windows combinations: active surveillance, passive surveillance, tactical display, ray tracing, torpedo warning.

### 3. BLOCK DIAGRAM OF THE SONAR AFTER MODERNIZATION

The block diagram of the ASW sonar SQS-56 after modernization is presented on Fig. 1. (For detailed compare with [10]).

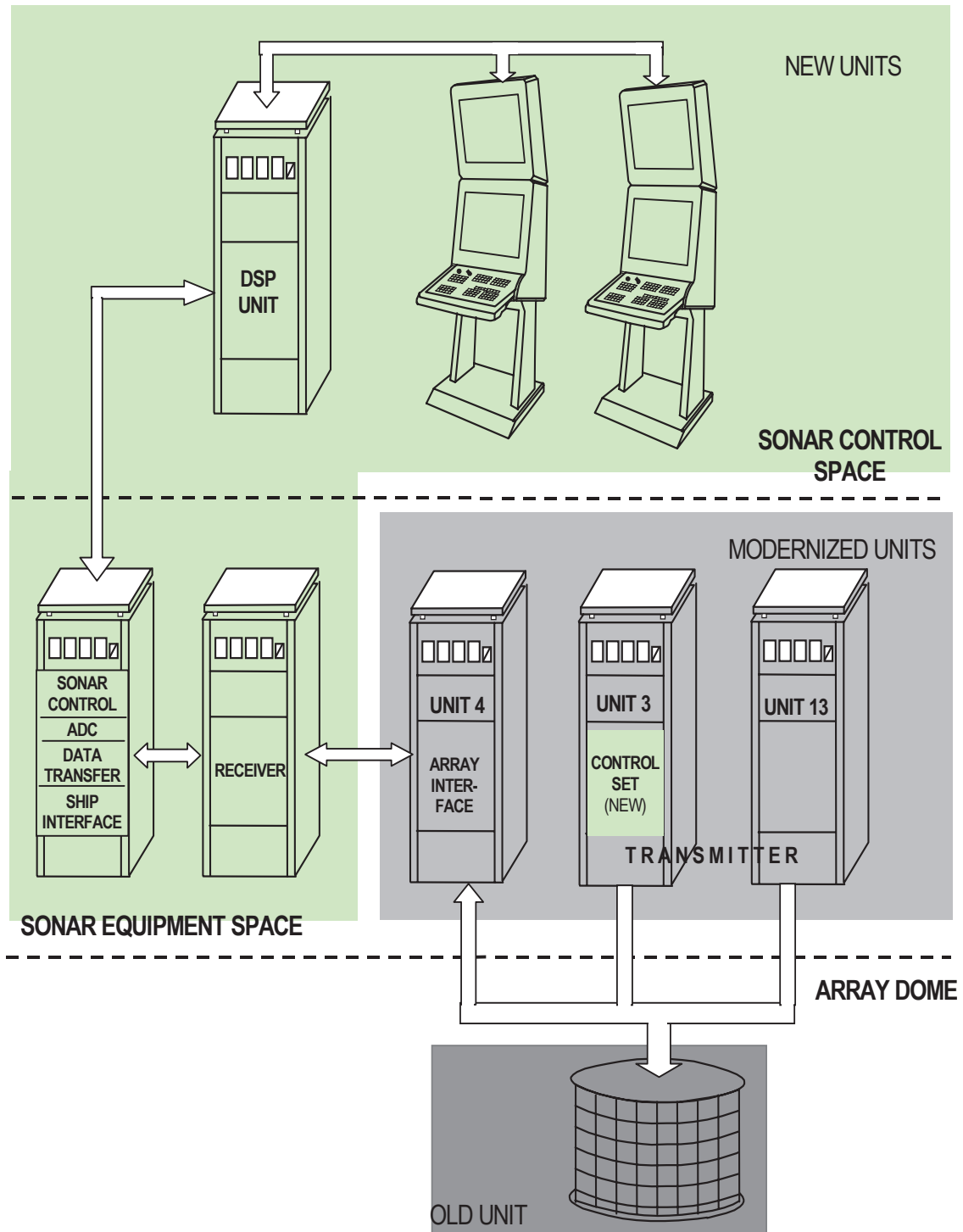


Fig.1. The block diagram of the ASW sonar SQS-56 after modernization



Fig.2. The Digital Signal Processing Unit and Operator Consoles of the modernized ASW sonar SQS-56 during the laboratory testing

#### 4. CONCLUSIONS

The modernization of SQS-56 sonar is the consecutive sonar modernization developed at Gdansk University of Technology - Department of Marine Electronic Systems. As a result of up to now developed modernization, Polish Navy ships and helicopters involved in NATO exercises were able to effectively work with the ships and helicopters from other navies equipped with state-of-the-art sonar systems. The achieved advantageous experiences suggest promising results of the ASW SQS-56 sonar modernization. What must be stressed is that the cost of the modernization is but a small fraction of the costs to install new devices.

#### REFERENCES

- [1] J. Marszal, R. Salamon, A. Stepnowski, Military sonar upgrading methods developed at Gdansk University of Technology, Proc. IEEE Oceans'05 Europe Conference, Brest 2005, [Electronic document], p. [1-6].
- [2] J. Marszal, L. Kilian, R. Salamon, A. Jedel, M. Rudnicki, Navy sonar's modernization developed in Gdansk University of Technology, Proc. TEHOSS 2005: IEEE International Conference on Technologies for Homeland Security and Safety, Gdańsk 2005, p. 57-62.
- [3] R. Salamon, J. Marszal, W. Leśniak, Broadband Sonar with a Cylindrical Antenna, ACTA ACUSTICA united with ACUSTICA, Vol. 92, 2006, p. 153-155.

- [4] W. Leśniak, J. Marszał, R. Salamon, K. Zachariasz, J. Schmidt, Method for improving multibeam sonar bearing accuracy, HYDROACOUSTICS 2009. - Vol. 12 p. 99-108.
- [5] J. Marszał, Z. Ostrowski, J. Schmidt, L. Kilian, A. Jedel, A. Schmidt, Time variable gain for long range sonar with chirp sounding signal, HYDROACOUSTICS 2007. - Vol. 10, p. 117-122.
- [6] W. Leśniak, J. Marszał, R. Salamon, M. Rudnicki, A. Schmidt, Digital mono-pulse method in cylindrical antenna, Archiwum Akustyki, Vol. 31, 2006, No 4, p. 357 - 363.
- [7] J. Marszał, W. Leśniak, R. Salamon, A. Jedel, K. Zachariasz, Passive sonar with cylindrical array, Archiwum Akustyki, Vol. 31, 2006, No 4, p. 365 - 371.
- [8] J. Marszał, W. Leśniak, R. Salamon, J. Schmidt, Electronic stabilization of beams in sonar with cylindrical array, HYDROACOUSTICS 2006. - Vol. 9, p. 119-124.
- [9] A. Raganowicz, L. Kilian, J. Marszał, Z. Ostrowski, A. Schmidt, K. Zachariasz, Formy zobrazowań w sonarze dalekiego zasięgu z anteną cylindryczną, Materiały LIV Otwartego Seminarium z Akustyki OSA'07, Rzeszów – Przemysł 2007, p. 208-209.
- [10] Technical Manual "Sonar Set AN/SQS-56", Naval Sea Systems Command, 1978.