

The project "A concept for constructing metrological infrastructure in underwater acoustics area at the Central Office of Measures" – assumptions and scope of the project tasks

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Abstract

The paper deals with the preparatory study concerning the project devoted to a constructing metrological infrastructure in the Central Office of Measures (GUM) underwater acoustic area. The results of the considered project planning stage, that is experiment planning and research and administrative activities are presented. These results which determines the possibility of further research on the reported topic and contains the description of the necessary activities and research elements are shortly discussed. Presented activities are divided into two parts: research and administrative. Initial research, concerned determining the impact of local seismic disturbances on water-filled basins, which constitute an important element of the infrastructure being developed is shown. Subsequent research results focused on determining the appropriate sizes and shapes of research pools and covering them with sound-absorbing materials using finite element modeling methods and performing actual tests are presented. Next, the issues of the design of research pools, necessary research equipment for calibration of sensors and underwater acoustic equipment, and a mobile testing ground for testing the underwater acoustic field of ships in the Bay of Gdansk are discussed. Some of the aforementioned issues were supported by a survey addressed to potential users as a part of the business justification of the project. Finally, a preliminary characterization of the elements of the future research and construction infrastructure as well as determining the costs and deadline for its implementation, based on the development of a Functional and Utility Program and a Feasibility study for the project was elaborated. The project schedule, developed in detail on the basis of preliminary research, received high marks from the reviewers of official evaluation body and was qualified for implementation.

1. Introduction

On the 2017, the authorities of the General Office of Measures in Poland, in accordance with development of its research and scientific mission, has taken a decision about extension of the areas of its activity. This extension covered, among other, the underwater acoustics area. It was a starting point of the works leading to the constructing of metrological infrastructure, which enables the calibration and research of the underwater acoustics sensors and underwater acoustic devices. In the first step, the Working Group for Underwater Acoustics, consisting of the representatives of the twelve national institutions engaged in underwater acoustics area was

appointed. The goals for this Working Group were defined as follows.

- Analysis of the world solutions in the considered area;
- Determining the demand for calibration and research works in the area of the underwater acoustics in Poland, realized in the cooperation with GUM;
- Identification and analysis of normative and standardization documents in the underwater acoustics area;
- Preliminary qualification of the structure and scope of the metrological infrastructure constructing in the area of the underwater acoustics, taking into account the results of the study visit in National Physical Laboratory (UK), in 2018;

- Analysis of possibilities of the planned infrastructure realization by national economic entities in cooperation with scientific centers;
- Elaboration of the preliminary road map of the underwater acoustics development in GUM;
- Presentation of recommendations to GUM authorities regarding to development of the underwater acoustics area in GUM.

A description of the initial works leading to development of the underwater acoustics in GUM has been included in [1]. On the basis of the positive recommendations of the Working Group for Underwater Acoustics, the GUM authorities decided to continue the aforementioned works. The recommendations of the cited Group also included a remark, that such extensive project with preliminary estimated budget at 20 mln PLN, requires to be began with the related smaller project. A goal of this smaller project should be oriented to carrying out of the preparatory study, concerning the identification of the necessary elements of metrological infrastructure, preparation of the preliminary projects of research basins (water tanks), completion of the calibration and auxiliary apparatus, as a well as business justification of the realized project together with estimation of its costs.

On 2nd November 2021, the Minister of Education and Science established the Polish Metrology program and announced the call for proposals [2]. The basic principles of the program are to:

- Support institutions of higher education and science, in cooperation with the President of the Central Office of Measures, hereinafter referred to as "GUM", scientific research or developmental work in areas related to metrology;
- Support projects aimed at enhancing the research capabilities of metrological institutions, strengthening intellectual capital, boosting the competitiveness of the Polish economy in areas strategic for the country, developing modern technologies, stimulating the development of metrology, in particular in the areas of health, environment, energy and advanced measurement techniques, as well as the development of digital technologies.

A consortium composed of Gdynia Maritime University (leader), Gdańsk University of Technology and the University of Gdańsk submitted a project to the competition entitled "A concept for constructing metrological infrastructure in underwater acoustics area at the Central Office of Measures".

The aim of this project is an elaboration of the concept for building the modern metrological infrastructure in the GUM's underwater acoustics area. This infrastructure have to serve to calibration of sensors and

underwater acoustic devices as well as to carrying out of the research and development works with cooperation with universities and scientific — research institutions, first of all for Polish, but looking wider for European and world maritime economy. A constructing of the metrological infrastructure in the underwater acoustics area is motivated and justified by the necessity of the completion of existing technological gap and a lack of capabilities within the range of the sensors and underwater acoustic devices calibration in Poland. At the present time GUM does not have any national calibration infrastructure in the area of underwater acoustics. A creation of such metrological infrastructure gives possibility for development and maintaining national patterns in the underwater acoustics area. It should be transmitted into development and modernization of research methods applied to exploration of sea resources and ocean research in the strategic directions from the point of view country development. These directions are crucial for development of the specializations of maritime universities and scientific — research institutions as well as for innovativeness and competitiveness of Polish enterprises. The article describes the planning stage of the analyses and research oriented to preparation of the plan of the required activities, and next the schedule of the project realization tasks in this way, that the achieved results will deliver necessary knowledge about the considered metrological infrastructure together with related business justification of the project. This approach enables for estimation of constructing the fully functional metrological infrastructure dedicated to the sensors and underwater acoustic devices in the area of underwater acoustics.

The paper is organized as follows. In the second chapter, we provide a short description of the importance of the metrological infrastructure in the area of underwater acoustics. The next chapter presents the structure and scope of the metrological infrastructure constructing, including planned research and administrative activities. In the fourth chapter the schedule for the implementation of tasks in the considered project is shown and discussed. Finally the last section concludes the study and includes recommendations.

2. The importance of the metrological infrastructure in the area of underwater acoustics

The calibration of sensors and devices in the area of underwater acoustics results from the following factors, characterized below:

- Development of marine research using underwater acoustic devices;

- The resulting increased interest of international metrological centers in the calibration of underwater acoustic sensors and devices;
- Identification of factors influencing changes in voltage sensitivity of sensors and entire underwater acoustic devices.

The importance of the development of the underwater acoustics metrological infrastructure [3] is closely linked with the intensification of operations in the Baltic Sea. This intensification is also correlated with Poland's economic development as well as maritime research in the following areas: extraction of raw materials from the seabed, development of wind energy, foundation of oil and gas drilling platforms, construction of gas transmission installations and underwater cables for international energy installations (SwePol, HARMONY Link), and expansion of ports as well as fishing and maritime transport. In parallel, marine research for economic and scientific purposes is being conducted by scientific institutions and private companies. In such work, sensors and devices that use the physical fields of the objects located in the marine environment are widely used. Physical fields are also called signatures. Fig. 1 shows the division of a ship's physical fields, which basically symbolises any object of anthropogenic and natural origin [4]. Disturbances in the

natural physical fields in the environment make it possible to detect an object (e.g., a shoal of fish, a marine mammal, an underwater vehicle or a ship) that has disturbed the energy state of the environment at the moment when the object appears.

Each object has its own unique energy characteristics, which distinguishes it from other objects – similarly to a fingerprint signature, hence the synonym for the physical fields of the ship (object): the signature of the ship (object). Physical fields (signatures) are divided into the lower (Underwater Signatures) and upper hemispheres separated from each other by the water surface, which are usually considered separately due to the fact that the various physical fields listed in Fig. 1 have different physical properties in water and in air. These fields, considered together, enable the detection, identification and classification of objects in the marine environment. One of the most important physical fields of the lower hemisphere is the underwater acoustic field due to its detection range of over 100 km in passive mode in the conditions of the Baltic Sea, at low frequencies [5].

Underwater acoustic monitoring of the marine environment is increasingly common due to the requirements of Directive 2008/56/EC of the European Parliament and of the Council [6], the so-called Maritime Strategy

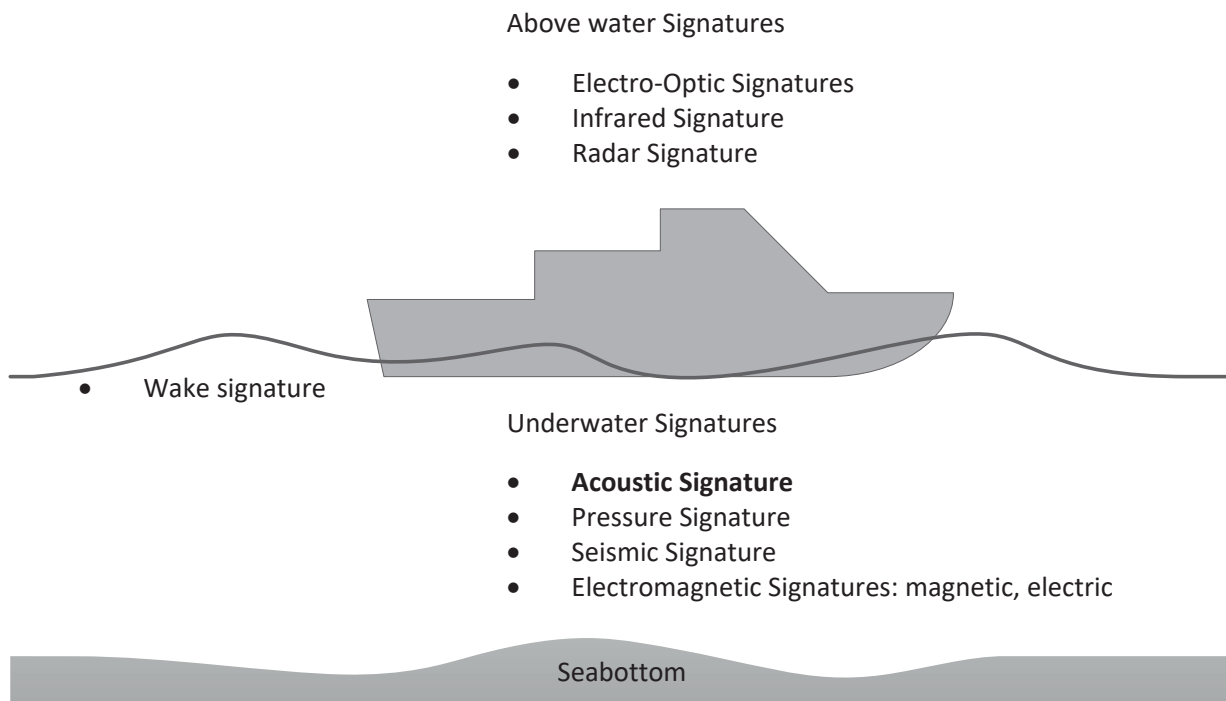


Fig.1. Subdivision of a ship's physical fields.



Fig. 2. A herd of about 150 marine mammals washed ashore in Western Australia, probably as a result of impaired echolocation caused by high levels of underwater noise. About half of the mammals did not survive [8].

Framework Directive (MSF) and the need to ensure the safety of the maritime infrastructure under construction, as well as to protect the maritime state border. This directive concerns the Chief Inspectorate of Environmental Protection, the Polish Armed Forces, the Border Guard and other state services, shipowners, owners of private companies and fishermen. Figure 2 shows a herd of marine mammals washed up on shore, possibly as a result of impaired echolocation caused by high levels of underwater noise from, for example, an underwater volcanic eruption or high-energy sonar used by active warships. A similar situation is occurring during the war in Ukraine, where dead dolphins and porpoises are being washed up on the shores of the Black Sea in astonishing numbers. Researchers studying the stranded mammals have linked this phenomenon with the increased activity of the Russian Navy due to the war in Ukraine. It is estimated that by May 2022, when all the dead marine mammals were counted, about 2,500 dead dolphins had washed up on the shore. Since most dead dolphins simply sink to the bottom of the sea and are never recorded, the actual number is much higher [7].

Due to the above, the interest of international metrological centers in the calibration of underwater acoustic sensors and devices is constantly increasing. In accordance with Directive 2008/56/EC, the quantity of acoustic recorders has grown [9].

The Marine Strategy Framework Directive (MSFD) requires Member States to develop marine strategies to achieve or maintain the "good environmental status" of EU marine waters. The MSFD defines Good Environmental Status (GES) as "the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive" (Articles 3-5) [10]. Meeting the requirements of GES means that various uses are made of marine resources at a sustainable level, ensuring their preservation for future generations. The Marine Directive contains 5 main elements: the initial assessment, the definition of good environmental status, the setting of environmental objectives, the monitoring program (ensuring regular assessment of the status of the marine waters concerned – this evaluation will be reliable if the underwater noise monitoring devices are regularly calibrated) and a program of action to maintain and/or improve the environment.

The quality of the collected data is very important. Guidelines for the calibration of hydrophones and recorders are included in [11]. It is recommended that a full laboratory calibration is undertaken before and after every major deployment or sea-trial.

There is general agreement among metrologists dealing with underwater acoustics that the progress of technical development in marine work is so rapid that

research institutions cannot keep up with examining the effects of this development. One of the reasons is the lack of appropriate underwater noise research tools and their reliability through calibration. Just a few years ago, the reason was the lack of widely available metrological infrastructure in the 10-2000 Hz range. The emergence of research programs, e.g. UNAC-LOW, initiated many useful initiatives aimed at developing appropriate metrological infrastructure. After 10 years of activities in this area, the infrastructure is still not widely available, so any action aimed at improving this state of affairs is valuable. One of such initiatives is the construction of metrological infrastructure in the area of underwater acoustics at the Central Office of Measures addressed not only to sensors calibration but also to entire underwater noise measurement devices. As mentioned above one of the most important projects carried out in recent years in the field of underwater acoustics is the EURAMET EMPIR project UNAC-LOW "Underwater Acoustic Calibration Standards for Frequencies Below 1 kHz" [12]. The goals of this project are the development of measurement consistency for the calibration of hydrophones and autonomous underwater noise recorders covering the frequency range of 20 Hz to 1 kHz. This frequency band covers the EU MSFD guideline requirements. In parallel with this work, amendments to the standard IEC 60565:2006 [13] were also developed: IEC 60565-1:2020 Underwater acoustics - Hydrophones - Calibration of hydrophones - Part 1: Procedures for free-field calibration of hydrophones [14] and IEC 60565-2:2019 Underwater acoustics — Hydrophones — Calibration of hydrophones — Part 2: Procedures for low frequency pressure calibration [15]. At that time, many metrological institutions around the world such as U.S. Navy's Underwater Sound Reference Division (USRD) – USA [16], National Physical Laboratory (NPL) – UK [17], Ocean Networks Canada (ONC) – Canada [18] were engaged in related research and for calibrating digital hydrophone at very low frequencies [19]. Moreover, National Institute of Ocean Technology (NIOT) – India [20], National Metrology Centre, Agency for Science Technology and Research (ASTAR) – Singapore [21], Dansk Fundamental Metrologi A/S (DFM) – Denmark [22], Central Office of Measures (GUM) – Poland [23] started building acoustic couplers for calibrating hydrophones at low frequencies and developed calibration technique for underwater transducers in free field conditions with results on an acoustical recorder like Swedish Defence Research Agency (FOI) – Sweden [24], which was intended to make underwater sound measurements at low frequencies more and more reliable.

Identification of factors influencing the changes in the sensitivity of hydrophones (dynamic pressure sensors) and entire underwater acoustic devices presented above are caused by:

- Adulteration (voltage sensitivity drift in time) – for B&K hydrophone [25] and for Reson hydrophone [26];
- Immersion of the sensors during measurements (different measurement depths should result in sensitivity correction in the measurement results) [27];
- The underwater structure on which the sensor is mounted (directly or at a distance) [28];
- Frequency range used (special attention should be paid to calibration in the frequency range used);
- Waves/tides for very low frequency ranges;
- other (e.g. method of calibration, attenuation of the electronic channel).

3. Structure and scope of constructing of the metrological infrastructure

Underwater acoustic devices may be used reliably and repeatably when they are regularly calibrated. One rough method is to compare heterogeneous measuring devices (e.g., of different types or belonging to different institutions). Fig. 3 presents the results of comparative tests run within the scope of the bilateral Common Sea Trial on Underwater Observation Systems 2018 (COST ISR18) project with measuring devices belonging to the Polish Naval Academy (PNA) in Gdynia [29] and the German Bundeswehr Research Center WTD 71 in Eckernförde, near Kiel. The comparison concerns the following physical fields: underwater acoustic [30], magnetic, electric and hydrodynamic.

Despite obtaining specific, comparable results (Fig. 3) – for example, for the magnetic field – the relative error of the resultant induction measurement was 0.06% (the German stationary measurement system belonging to WTD 71 was used for reference), and for the underwater acoustic field the difference in the measurement of the 1/1 octave spectrum was up to 4 dB. These proved to be of limited use for those involved in the experiment because while acquired knowledge enables joint international measurement projects, it does not provide sufficient information on the measurement uncertainty of the domestic (as defined by the experiment partners) part of the measuring devices. For this, it is necessary to refer the obtained results to national standards in accordance with the strict procedures described in the calibration instructions of the National Metrology Institute (NMI – National Metrology Institute), which in Poland is GMU. There is no research laboratory in Poland that can calibrate underwater acoustic devices at the level of other NMIs. Therefore, the construction of

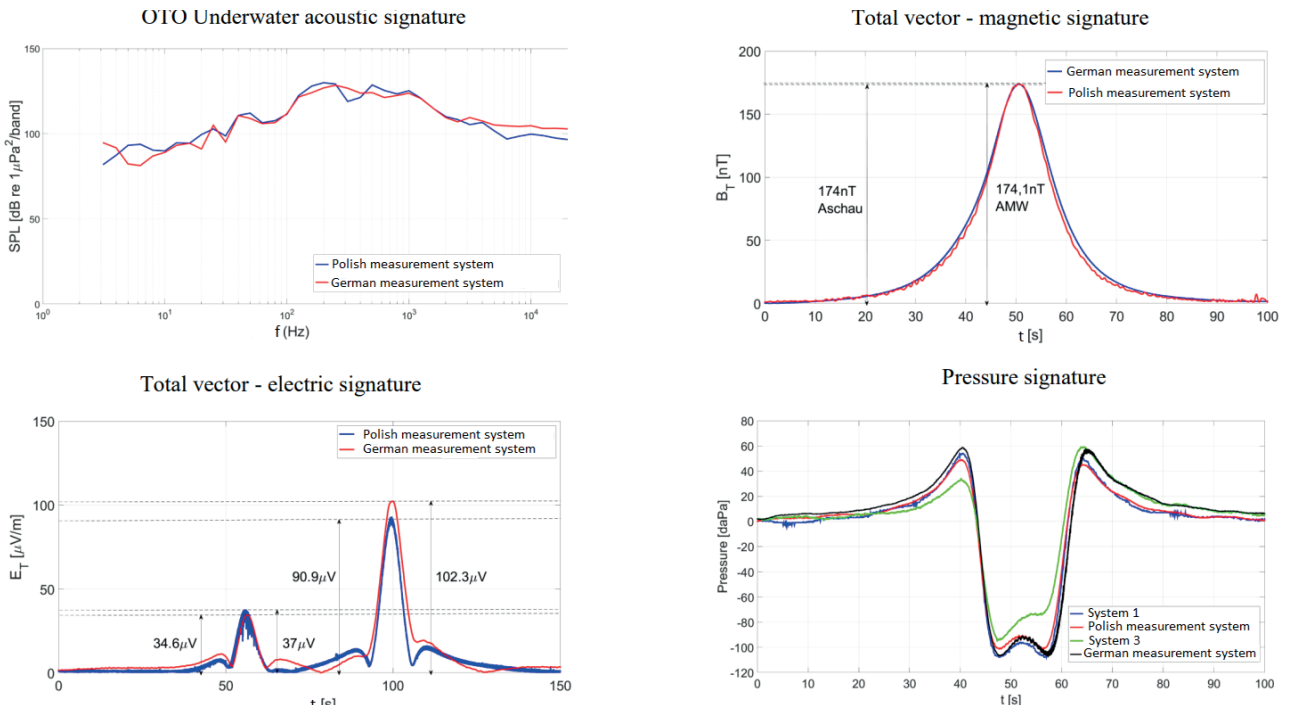


Fig. 3. Results of comparative studies carried out within the COST ISR 2018 project.

metrological infrastructure for underwater acoustics was initiated, and the proposed tasks described in the article are an important element of this project.

Despite the existing hydrophone calibrators described in Chapter II, it is not possible to calibrate all hydrophones in recognized laboratories due to the calibration time of up to several months and costs. Each calibration laboratory has its limitations as to the number of calibrated hydrophones — it is not possible to send several dozen hydrophones for calibration to metrology centers outside the country every year. After the analysis, it seems that the only solution is to calibrate only the so-called reference hydrophones, which are then used to calibrate underwater acoustic sensors in a national center using a comparative method, or developing a national primary method for hydrophone calibration.

A summary of the preparatory work for developing metrological infrastructure for underwater acoustics carried out by the Working Group on Underwater Acoustics, is illustrated by the action plan presented in Tab.1.

Ensuring the reliability of underwater acoustics measurements for civil and military applications is critical. To meet this challenge, the Central Office of Measures undertook to construct appropriate metrological infrastructure in Poland for underwater acoustics and to establish the Underwater Acoustics Laboratory (Laboratorium Akustyki Podwodnej — LAP)

in Gdynia-Witomino, operating within the Independent Laboratory of Acoustics, Ultrasounds and Vibrations of GMU (currently the Department of Mechanics and Acoustics). This unit will deal with maintaining measurement standards, providing calibration services, as well as conducting research and development work in the field of underwater acoustics. The first stage (Table 1) involved establishing the Working Group for Underwater Acoustics, bringing together experts from institutions with expertise and experience in the field of scientific activity for metrology in the area under consideration. The working group focused on identifying metrological needs for underwater acoustics and developing a business plan as well as a road map for the planned project.

The experience of the experts gathered in the Working Group on Underwater Acoustics shows that many institutions are interested in calibrating the measurement equipment they use for underwater acoustics, including the measurement of non-acoustic quantities (e.g., conductivity and sea water density, air temperature and humidity). Most of these devices are hydrophones (about 160 items), some of them are installed in dedicated devices or on vessels. The interest of the institutions in question will be explored during the project by means of a surveys addressed to these institutions.

One of the key issues for underwater acoustics is the method chosen for calibrating underwater acoustic

Tab.1. Action plan of the working group appointed to prepare a project dedicated to developing metrological infrastructure for underwater acoustics

No.	Type of action	Term	Place
1	Establishment of the Working Group for Underwater Acoustics at GUM	11.2017	Warszawa
2	I meeting	28.11.2017	GUM, Warszawa
3	Study visit at the NPL (National Physical Laboratory)	15.05.2018	Teddington, Londyn
4	II meeting	05.02.2018	CTO Gdansk
5	III meeting	25.05.2018	PNA Gdynia
6	IV meeting	05.02.2019	OUM Gdansk
7	V meeting	17.11.2021	GU Gdansk
8	VI meeting – Kick-off meeting of the Polish Metrology project	27.09.2022	GMU Gdynia
9	VII meeting – Project review after half a year of implementation	15.02.2023	GMU Gdynia
10	VIII meeting – Project closing meeting	20.09.2023	GMU Gdynia

sensors (hydrophones). In Fig. 4, the frequency ranges are marked with colours that correspond to the frequency ranges of hydrophones from two recognised manufacturers – light blue for Brüel & Kjær (B&K) and grey for Reson. In order to calibrate, for example, the B&K 8105 hydrophone in the full frequency range, it is necessary to calibrate using the methods listed in points 1 to 4 (Fig. 4) – i.e. four methods, each requiring a different specialised metrological infrastructure. Calibration of the B&K 8106 hydrophone in the full frequency range requires the application of 3 methods, while the TC 4035 hydrophone needs one method (small anechoic basin).

Based on an analysis of the metrological infrastructure of other recognised National Metrological Institutes (NMIs) (which in Poland is GUM) dealing with underwater acoustics, including the NPL (National Physical Laboratory in Great Britain) as well as an analysis of underwater acoustic equipment used by state institutions and private companies, performed via a questionnaire addressed to these bodies, along with literature analysis and discussion, metrological infrastructure was selected for underwater acoustics, as specified in Table 2.

The scope of metrological action in terms of underwater acoustics focuses on metrological support in various areas of economic and scientific activity, including:

- Requirements of the Directive of the European Parliament and of the Council 2008/56/EC, known as the Marine Strategy Framework Directive;
- Work related to measuring underwater noise in sea and inland waters – mainly in the Baltic Sea;
- Measurements of noise emitted to water by vessels (mainly ships, vessels, fishing vessels). Measurements carried out while the vessel has been approved to sail are important, and the requirements for acceptable noise emission must be met by the vessel;
- Monitoring the underwater environment: e.g., mapping underwater noise with regard to EU water noise regulations;
- Calibration of underwater acoustic transducers and devices for civil and military applications.

The next necessary step is to obtain funds to construct metrological infrastructure for underwater acoustics at GUM, the Underwater Acoustics Laboratory, located in Gdynia-Witomino. Visualisations of the construction part of the metrological infrastructure in question assigned to the Gdynia-Witomino location are shown in Fig. 5. Before this is possible, it is necessary to specify needs based on the development of "A concept for constructing metrological infrastructure in GUM's underwater acoustics area" project run under the auspices of the Polish Metrology program announced by the Ministry of Education and Science.

Tab.2. Metrological infrastructure for research on underwater acoustics

Lp.	Device / object	Application	Frequency band / method
1	Low-frequency acoustic coupler station [23]	calibration of underwater acoustic sensors	in the range of 10 Hz – 2 kHz using the vibrating water column method – in progress with GMU's own funds
2	Very low frequency acoustic coupler station	calibration of underwater acoustic sensors	in the range of 0,01 Hz – 10 Hz
3	Small measuring pool 3 x 3 x 4 m	calibration of ultrasonic sensors and devices	in the range of several kHz – 1 MHz
4	Large measuring pool 10 x 15 x 10 m	calibration of ultrasonic sensors and devices	in the range of several hundred Hz – 1 MHz
5	Marine training area with research infrastructure in the quiet zone (actual conditions for equipment operation)	calibration of ultrasonic sensors and devices, adjustment of sonar and communication systems	in the range of several hundred Hz – 1 MHz
6	Training area on a lake (large water reservoir) with research infrastructure in the quiet zone (model conditions for the operation of devices)	calibration of ultrasonic sensors and devices, adjustment of sonar and communication systems	in the range of several hundred Hz – 1 MHz

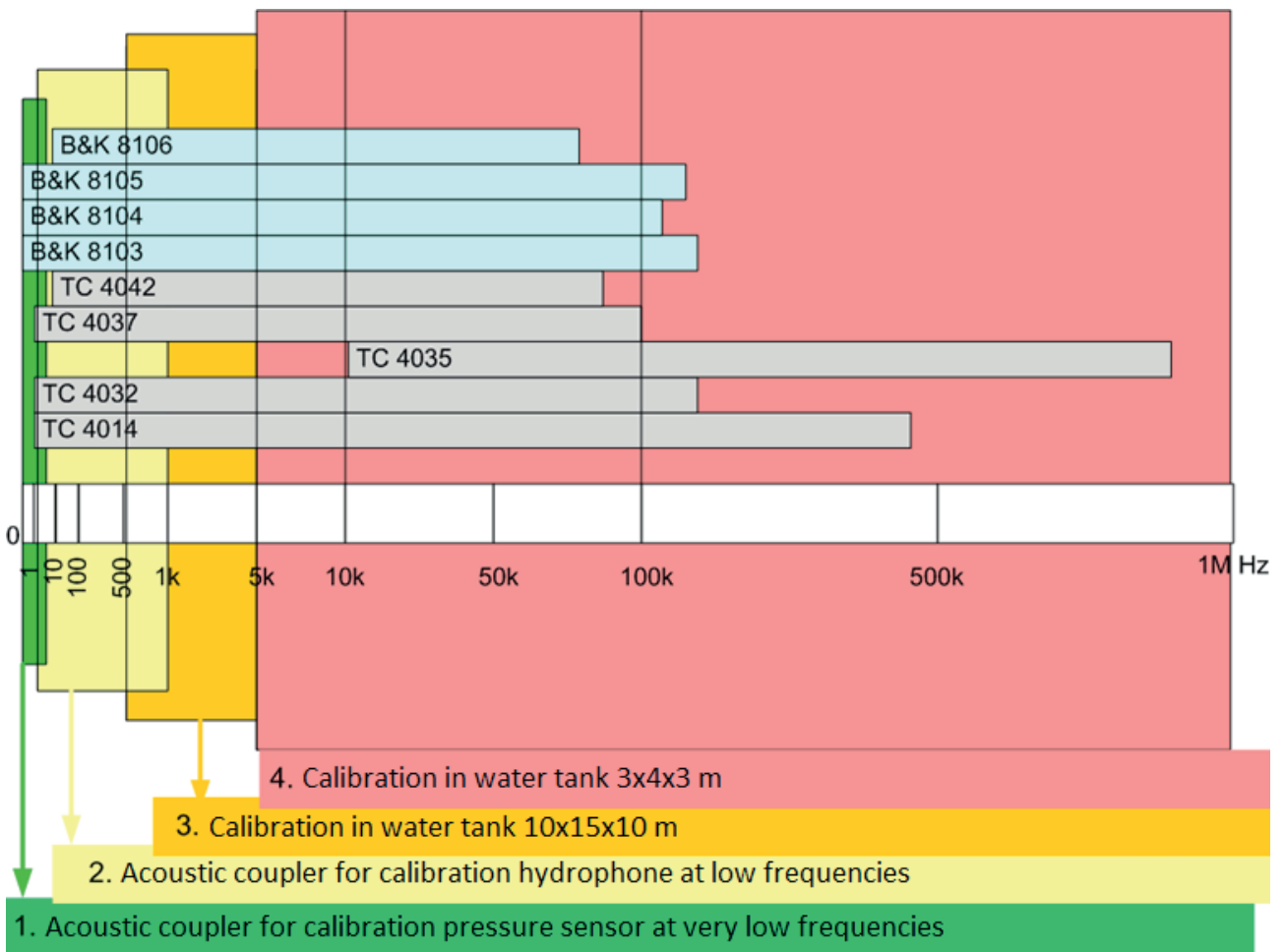


Fig. 4. Selection of the calibration method depending on the required calibration frequency of the underwater acoustic sensor.

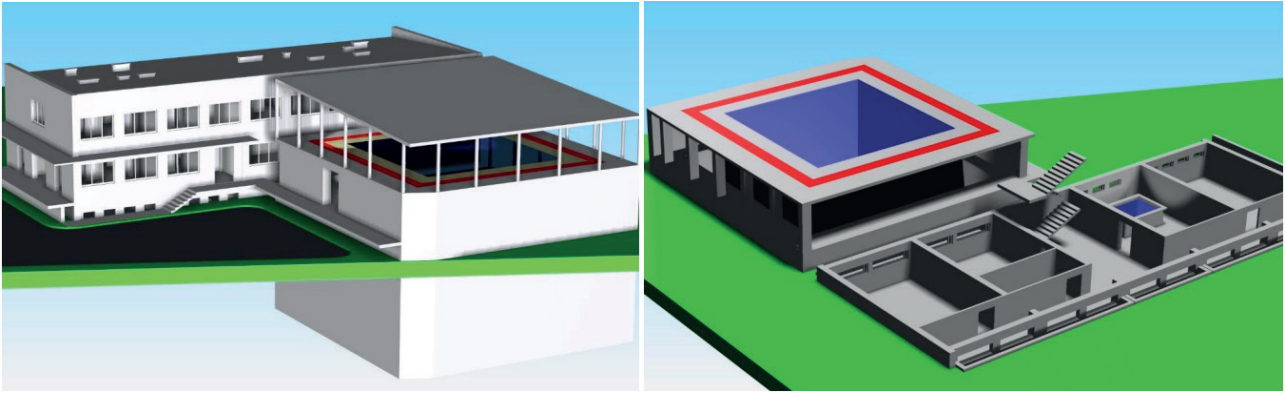


Fig. 5. Preliminary visualisation of the construction part of the metrological infrastructure for underwater acoustics research. On the left is the OUM Gdansk building in Gdynia-Witomino – the first floor is at the disposal of the Underwater Acoustics Laboratory of the Department of Mechanics and Acoustics at GUM. In the foreground, the building of a large measuring basin is visible. The right side shows a cross-section of the building with visible measuring basins: large (outside the existing building) and small (in the basement).

4. Schedule for the implementation of tasks in the project

To complete the assignment, a consortium was established: Gdynia Maritime University as the leader, along with Gdansk University of Technology and the University of Gdansk. Subcontractors – institutions in the Working Group – were also expected to participate in the project.

The project “A concept for constructing metrological infrastructure in underwater acoustics area at the Central Office of Measures” project is run on the basis of scientific research aimed at studying the feasibility of the project and verify the purposefulness and efficacy regarding the application of individual elements of the future metrological infrastructure.

The scientific research will include:

- Seismic surveys of the ground in the Underwater Acoustics Laboratory (LAP) area and determination of the impact of external disturbances on the structures of measurement basins;
- Model studies using the finite (FEM) and boundary (MEB) element methods to examine the shape of pools and sound-absorbing materials in order to obtain the anechoic properties of the measurement basins;
- Experimental tests run in the measurement basin on selected sound-absorbing materials to determine the sound absorption coefficient in the frequency range common to the large and small measurement basin;
- Development of surveys addressed to the potential users of the infrastructure regarding future metrological needs: i.e., the types and number of acoustic transducers and measuring equipment;
- Other studies necessary to assess the degree to which the developed metrological infrastructure may be used;

- Development of an up-to-date road map, including scientific and research works and projects with the potential participation of GUM and/or the use of future LAP infrastructure.

The results of the performed tests will verify whether the construction of metrological infrastructure for underwater acoustics at GUM is a feasible concept and will help update the designs of the measuring basins and the current LAP infrastructure to the needs of the new, concept once verified. The research and the functional-utility program of the infrastructure developed within the project, as well as a feasibility study including a cost estimate, will make it possible to apply for funds for a research or infrastructural project for the entire infrastructure covered by the “A concept for constructing metrological infrastructure in underwater acoustics area at the Central Office of Measures”.

5. Conclusions

The development of a detailed concept for the construction of metrological infrastructure for underwater acoustics at GUM – i.e., the design of this infrastructure and estimated cost – is the subject of the project submitted by the Consortium. An important element of the submitted project is scientific research aimed at verifying the purposefulness and efficacy of the main elements of this infrastructure that affect the final shape and use of sound-absorbing materials ensuring echo-free properties of the water tanks for the calibration of sensors and underwater acoustic devices, and thus their construction and execution costs.

The project will yield a compendium of knowledge on the building of metrological infrastructure, the construction of infrastructure elements based on scientific research, adaptation of the existing LAP building to the needs of research on underwater acoustics at GUM as

well as cost estimates. This will enable an application for funds for a research or infrastructural project for the entire infrastructure covered by "A concept for constructing metrological infrastructure in underwater acoustics area at the Central Office of Measures" project.

Based on an analysis of existing solutions, it is expected that the metrological infrastructure developed within the submitted project will be one of the most modern solutions in its field worldwide. The GUM's Underwater Acoustics Laboratory is assumed to be international in scope. The estimated costs of calibrating an underwater acoustic sensor (hydrophone) in GUM are currently lower than equivalent costs abroad, which should translate not only into an increase in interest in calibrating underwater acoustic sensors in LAP, but also in scientific research of scientific and commercial institutions providing services based on the use of sensors and devices. for underwater acoustics. Currently, these institutions use foreign laboratories, which forces breaks in the use of research equipment for underwater acoustics testing or in having additional calibrated equipment for several months. It is assumed that the location of LAP in Gdynia, in close proximity to the main national institutions dealing with sea research using underwater acoustic methods, will significantly shorten the calibration time.

Domestic producers of underwater acoustic equipment e.g. Gdansk University of Technology or the Maritime Technology Centre, will be able to develop new solutions based on detailed underwater acoustic studies with access to a large water tank with anechoic properties. These activities should improve the competitiveness of national scientific and industrial institutions in the field of underwater acoustics products on the international market.

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