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Problematic issues in the navy of the Armed Forces of Ukraine's training for the future network-centric undersea warfare

Serhii Hrynchak
candidate of technical sciences (PhD in engineering)
Chief of the Scientific and Research Directorate for the Navy Armaments
and Military Equipment Development
Research Centre of the Armed Forces of Ukraine 'State Oceanarium' of the Navy Institute of the
National University 'Odesa Maritime Academy'
65029, Didrihsona, 8, Odesa, Ukraine
e-mail: grinserg69@gmail.com
ORCID: 0000-0001-6627-7780

Borys Kapochkin
Candidate of Geological and Mineralogical Sciences (PhD in geology and mineralogy)
Leading researcher at the research branch for the development of armaments and military
equipment of the Scientific and Research Directorate
for the Navy Armaments and Military Equipment Development
Research Centre of the Armed Forces of Ukraine 'State Oceanarium' of the Navy Institute of the
National University 'Odesa Maritime Academy'
65029, Didrihsona, 8, Odesa, Ukraine
e-mail: tsb1@ukr.net
ORCID: 0000-0002-7004-3503

Abstract. Within the framework of execution of the Naval Doctrine of Ukraine for the period up to 2035, in order to create the basis for its own undersea warfare concept, an analysis of Ukraine's capabilities to comply with the main operational concepts of the US Navy's undersea warfare was carried out. It is determined that the first three of the five operational concepts could be applied to ensure dominance in the undersea space of Ukraine's responsibility zone in the Azov-Black Sea region, and the last two operational concepts are intended for use in distant war theatres. The contradictions that have arisen as a consequence of disproportionate trends in the undersea warfare methods development between individual operational concepts of undersea warfare are identified. Taking into consideration the identified contradictions, the US Navy's undersea warfare concept has been adapted to the Ukraine's geopolitical and geographical conditions. The research goal is to identify promising warfare assets in undersea space, the use of which will allow Ukraine to dominate undersea space within the exclusive economic zone borders in the Black Sea. The main research objective is to correctly select priorities when elaborating a strategic plan for the submarine fleet development of the Navy of the Armed Forces of Ukraine.

Ukraine is a maritime state and should define its own doctrine, concept and strategic plan for participation in the future undersea warfare, primarily in the internal seas war theatre

Keywords: undersea network-centric warfare, seabed warfare, undersea space dominance, undersea situational awareness, undersea warfare battlefield organisation.

Introduction

Undersea warfare is one of the three naval warfare operational domains, which involves a triad of underwater, surface, and air (including space) forces and assets. In the underwater space, network-

centric warfare is conducted with the use of specific military-technical assets that form its information and sensor layers, guided and autonomous weapons that form its executive layer (Peshekhonov V.G., 2016), (Baulyn V., 2009). War on the seabed (seabed warfare), the object of which is the seabed infrastructure, is considered separately, but, in our opinion, is an integral part of undersea warfare. The emergence of the new term ‘seabed warfare’ is related to the danger that, in the conditions of a new hybrid warfare type, suddenly and unexpectedly appeared in the sabotage against such components of the rapidly expanding seabed infrastructure in the world oceans as gas pipelines and fibre optic cables.

Warfare in underwater space is significantly different from warfare in other naval warfare operational domains. Underwater, there is extremely low situational awareness, challenging positioning, and low speed and capacity of hydroacoustic communications. In underwater space, all of this, on the one hand, narrows the range of destruction assets that are effectively used during combat actions at sea, on land and in the air, and, on the other hand, significantly increases the ability to covertly and anonymously use high-precision autonomous weapons from underwater, including when enemy targets are on land and even in the air.

The Navy of the Armed Forces of Ukraine's training for the future network-centric undersea warfare is associated with defining the underwater space as one of the modern warfare operational areas. The current undersea warfare experience shows that submarines are the most dangerous and at the same time the less vulnerable undersea warfare weapon. For this purpose, they are nuclear weapons carriers and have received the strategic level weapon status. The invulnerability of modern submarines to existing anti-submarine warfare (ASW) assets was confirmed by an incident involving a russian navy submarine in Swedish territorial waters (Baltic Sea) with depths of up to 100 m, which took place on 19th of October 2014. That day, Swedish radio reconnaissance equipment detected information about the time and approximate area of the submarine's accident. During several days, a search was conducted unsuccessfully in the area of 30×60 km around the submarine's accident site. As a result, the submarine successfully left the accident area (Sweden calls off suspected submarine search., 2014).

The Ukrainian war experience against the russian black sea fleet shows that over the two years of combat actions at sea, up to 30% of the surface vessels of the black sea fleet were destroyed by Ukraine. At the same time, not a single submarine, not a single autonomous unmanned underwater vehicle, not a single autonomous weapon unit that can be deployed in underwater space was destroyed at sea. It should be emphasised that autonomous weapons, the development of which was subject to certain legal restrictions until recently, are becoming the most effective in a new hybrid warfare due to the integration of artificial intelligence. In underwater space, the autonomous weapon's use is facilitated by the secrecy of its deployment on the seabed and the corresponding simplified ‘false flag’ use. Underwater autonomous weapons are seabed missile launchers, all types of mines, including modern missile and torpedo mines, autonomous underwater vehicles (multipurpose, strike, reconnaissance, transport), etc.

The relevance of the Navy of the Armed Forces of Ukraine's training for the future network-centric undersea warfare is confirmed by the losses the global economy suddenly and unexpectedly began to suffer as a result of a new hybrid type of undersea warfare. Over the past three years, a number of high-profile sabotage incidents have taken place in underwater space:

‘cutting’ off 66 km of submarine cable near the Norwegian coast (15.04.2021) (Who stole 10 tonnes of Norwegian cable at a depth of 2.5 km?, 2021)

- explosions of the Nord Stream 2 subsea gas pipelines in the Baltic Sea (26.09.2022) (russian warships were in the Nord Stream area several days before the explosions - media, 2023);

- breaks in fibre optic cables and a gas pipeline in the Baltic Sea (08.10.2023) (Finland reported damage to a russian cable in the Baltic Sea, 2023);

- breaks in fibre-optic cables in the Red Sea (27.02.2024) (Houthis attacked submarine internet cables connecting Europe and Asia, 2024).

In the current circumstances, the French Navy adopted a strategy for seabed warfare on 14th of February 2022, and NATO created a new special structural unit, the Undersea Warfare Centre, on 16th of June 2023. Despite these actions, all civilian fibre-optic submarine networks, special communications cables, and pipelines are in constant danger and will remain so indefinitely.

Ukraine is a maritime state and must define its own doctrine, concept and strategic plan for participation in the future underwater warfare, primarily in the internal seas war theatre.

Literature review

Currently, the undersea warfare doctrine, i.e., sustainable dominance in the underwater space, is realised through the network-centric warfare 'system of systems' implementation, which aims to use information superiority and thus to obtain the ability to conduct combat actions at a high-quality level. The 'system of systems' (hereinafter referred to as SoS) concept is considered in terms of sensor systems interaction, command and control system and high-precision weapons command in order to provide situational awareness, rapid situation assessment, and differentiated weapons use.

The research is aimed at identifying perspective warfare assets in underwater space, the application of which will allow Ukraine to dominate underwater space within the exclusive economic zone in the Black Sea's borders.

Achieving the set goal requires an analysis of the world's leading countries' experience. The undersea network-centric warfare US Navy's general concept is based on the implementation of five operational concepts (David R., 2018):

1. Advanced Undersea Warfare System, (hereinafter AUWS), which provides for the application of an underwater unmanned systems' distributed network that can be quickly deployed and configured to form a combat space and establish an access denial zone;
2. Forward Deployed Energy and Communications Outpost, (hereinafter FDECO), which provides for the construction of an underwater docking station network, underwater communication and navigation stations;
3. Modular Undersea Effectors (hereinafter referred to as MUSE) is a module system containing warfare assets capable of deploying communication nodes, weapons, distractors, false targets, traps, etc;
4. HYDRA is a logistics system for supporting combat actions in underwater space, using ultra-large autonomous unmanned underwater vehicles;
5. Upward Falling Payloads (hereinafter referred to as UFP), which provides for weapons, ammunition and military equipment pre-hidden on the seabed for further, time-delayed, distance activation in order to create information, sensor and executive layers of network-centric warfare.

The research main goal is to correctly select priorities in the strategic plan elaboration for the submarine fleet development of the Navy of the Armed Forces of Ukraine. At the current technological stage of society's development, all the world's leading countries are in a conceptual confusion state, as the ways to achieve dominance in underwater space over other countries are not defined. According to The Program Executive Officer for PEO (USC) (U.S. Department of Defence, 2022), '...in some of the undersea warfare strategic areas, a revolutionary technological leap is needed that is insurmountable for the enemy'. This can be achieved by mastering new energy support physical principles in underwater space, implementing priority developments in the area of 'artificial intelligence', and developing weapons that apply new strike physical principles.

According to the results of our analysis, in NATO countries, the realisation of the undersea warfare concept at the strategic planning level includes the following tasks:

- significant increase in the undersea warfare assets' autonomy;

- introduction of artificial intelligence into the underwater warfare assets command and control systems, including autonomous weapon command and control systems;
- creation of sensor networks of the information and underwater network-centric warfare sensor layers and their carriers;
- development of new weapons physical principles being effective in underwater space.

Information on the undersea warfare planning tactical level is contained in the annual activity plans of the Defense Advanced Research Projects Agency (DARPA) (Department of Defence Fiscal Year, 2023).

The fact that a ‘revolutionary technological leap’, insurmountable for the enemy, can lead to an unexpected victory on the battlefield is confirmed by successful combat experience of the Javelin ATGM used against russian armoured vehicles as a high-tech weapon sample. The use of Javelin ATGMs was the main reason for the successful spring-summer offensive campaign of the Land Forces of the Armed Forces of Ukraine in 2022. The russian army, which in some areas has mastered the 5th technological level and is armed with modern surface vessels, is being defeated in naval battles with Ukraine, equipped by the 6th technological level countries. Ukrainian analogues of the Maritime Tactical Systems (MARTAC) are highly effective in destroying modern russian surface vessels. The integration of robotics with ‘artificial intelligence’ on the battlefield, meaning loitering munition, thanks to automatic target identification technology, displaces snipers, for example. This has fundamentally changed the combat actions' character directly on the front line. It is worth pointing out that the first loitering munitions were used in a naval battle on 25 October 1944. It was a group of five Japanese kamikaze jets that sank the aircraft carrier St. Lo in one battle and disabled three other aircraft carriers. They differed from modern robotic loitering munitions in having the pilot's intelligence, which is now being replaced by artificial intelligence. At that time, not only aircraft were used, but also manned missiles ‘Yokosuka MXY7 Oka’ to hit maritime targets, manned torpedoes ‘Kaitaen’ and kamikaze speedboats.

Materials and Methods

The formulation of the undersea warfare concept requires certain knowledge of differences between combat actions over and under water. Compared to airspace, underwater space is ineffective for electronic intelligence, electronic warfare, aerospace reconnaissance, and cyber weapons, which are successfully used over sea, on land, and in the air. Unlike airspace, the negative weather conditions affecting combat actions underwater are significantly minimised. Through the fact that water is practically incompressible, the main damage physics principle, apart from direct hit, is overpressure. It is important to remember that an increase in the explosive's mass weight does not lead to a proportional increase in the destruction radius in water. In other words, only highly precision weapons that guarantee a direct strike are most effective in underwater space.

In addition, the water environment density is 800 times higher than the air density, which reduces the kinetic weapons effectiveness, reduces the threats from chemical and bacteriological weapons, from underwater explosion light and heat waves, and from radiological contamination after a nuclear underwater explosion.

At the current scientific and technical level, the most dangerous weapons of undersea warfare are still nuclear submarines such as Virginia-class, autonomous unmanned strike vehicles with nuclear power plants such as Poseidon type, deep-sea ballistic missiles such as Skiff type (Level of modern weapons, 2013), mines, mines-torpedoes such as Hammerhead type (Hammerhead: torpedo of the future, 2020). These underwater weapons types are capable of operating autonomously, using their own information and sensor support, i.e., they do not require additional seabed infrastructure, which provides enhanced communication relay capabilities, increased underwater positioning precision, and enhanced target detection and identification capabilities.

According to the future undersea warfare operational concepts AUWS and HYDRO, the nuclear submarines will be replaced by ultra-large autonomous unmanned underwater vehicles (hereinafter LDUUVs) (Saballa J., 2023) with a completely new power supply physical principle (Hollings A., 2022), which will be the main weapons and military technical assets carriers of undersea network-centric warfare. The AUWS operational concept is complemented by the seabed infrastructure of the future FDECO network-centric warfare information layer.

It is important to take into account that in the water environment, compared to the air environment, there are restrictions on electromagnetic waves distribution in the radio and optical (visible and infrared spectrum parts) spectral ranges, which in airspace are effectively used for communication and in radio and laser location. Unlike distribution in the atmosphere, in the water environment, laser and radio communication (GHz band) is practically limited to a 10 m range. This makes it impossible to use GPS and Starlink, which are successfully used on the battlefield in airspace. At the present stage, only acoustic waves are an alternative to electromagnetic waves in underwater space.

Results and Discussions

Let's consider the FDECO operational concept principle on Seaweb system example, which is applied in NATO countries (Rice J, 2003), (Reed M., 2006). Seaweb networks connect stationary and mobile nodes distributed over a large aquatic area (Rice J, 2005).

A Seaweb test of the sound underwater communication system took place in 2003 in the Gulf of Mexico by the US and Canadian joint fleets (US Navy Seaweb programme, 2024). Underwater communication was carried out through the communication relay by a sea-bed hydroacoustic modem network.

The situational awareness provided by the network-centric warfare sensor layer depends crucially on the positioning accuracy of underwater vehicles, as foreseen by the FDECO concept. The Seaweb long baseline principle (LBL) seabed navigation network of hydroacoustic beacon was tested in 2005 (Diogenes Laertius, 2019).

It should be noted that underwater hydroacoustic data communication assets are characterised by low signal-to-noise ratio, limited data volumes and low speed. In addition, the overcoming negative impact of refraction problem needs to be solved, by means of which acoustic shadow zones appear in the underwater space (PubMed, 2009), (Kapochkina A., 2022).

As it has been shown, the seabed infrastructure is the main seabed warfare target, so the creation of information and sensor layers of the future network-centric warfare requires the foresight of its covert use and/or protection methods.

The Navy of the Armed Forces of of Ukraine's training for future network-centric undersea warfare should be carried out within the NATO countries' general concept framework. However, it should be considered that the 5 undersea warfare operational concepts were formulated gradually, extending over time from the first to the fifth. When the undersea network-centric warfare concept was implemented in the form of a distributed network of underwater unmanned systems (AUWS) that perform its sensor and executive layers' functions, the need for reliable communication, electricity power restoration, and sufficient positioning accuracy ensuring became apparent. Only then was FDECO implemented, which provides for the creation of an SoS information layer, thus significantly improving its general concept's characteristics. Only after the information, sensor and executive layers of network-centric undersea warfare were created, the idea of a auxiliary warfare assets system's creation MUSE arose. In conditions of gradual (dynamic) development of the undersea warfare general concept, some principles of the previous operational concept AUWS may contradict the next operational concept's principles - FDECO. That is, the AUWS operational concept's further development may require a significant improvement of the FDECO operational concept, or even its rebuttal. An analysis carried out of the dynamic transformation specifics of

NATO's general concept of future undersea warfare gives grounds to state that dogmatic adherence to these 5 operational concepts is inadmissible in preparing the Ukrainian Navy for future undersea warfare. The considered NATO undersea warfare operational concepts are aimed at achieving dominance in the underwater space, which includes both defensive and offensive tasks. The first three undersea warfare operational concepts deal with the general tasks of shaping the battle space and establishing an access denied zone. The fourth and fifth operational concepts solve these tasks in a distant battlefield theatre, which do not expand to the responsibility area of the Navy of the Armed Forces of Ukraine in the Azov Sea and in the Ukraine's exclusive economic zone in the Black Sea.

Let's consider some specific examples of the modernisation dynamic impact of the AUWS operational concept on the FDECO operational concept's relevance. Currently, in the Navy of the Armed Forces of Ukraine's area of responsibility in the Azov-Black Sea region, underwater autonomous unmanned vehicles Remus-100 are used for the covert detection and identification of sea mines' tasks, which require high-quality communication for remote underwater target identification and for building a minefield map require precision positioning. Thus, at the current scientific and technical level of the PMO Navy of the Armed Forces of Ukraine, the AUWS operational concept is coordinated with the FDECO operational concept. But at the scientific and technical level of NATO's PMO, littoral combat ships (hereinafter LCS) already have Remote Multi-Mission Vehicles (hereinafter RMMV) in service, which do not demand an underwater information layer of network-centric warfare, because they are constructively able to use Starlink and GPS while in underwater space (Jimenez R., 2010).

It is worth noting that a similar situation is observed in the ASW area, where NATO countries have already deployed three underwater acoustic direction-finding centres in the world's oceans at the level corresponding to network-centric undersea warfare: IMOS, EGO/Coriolis, IOOS (Active Global Glider Tracks, 2024), (IMOS Ocean Gliders, 2024).

In order to ensure the covert use of underwater network-centric warfare information and sensory layers' sensors operating on a passive basis, we propose the use of mobile platforms. Promising networked hydroacoustic ASW systems operating on the primary acoustic field are considered to be manoeuvrable systems with the use of noiseless above- and underwater autonomous vehicles (gliders type) (IMOS Ocean Gliders, 2024). For assets operating exclusively on the positional principle (hydroacoustic lighthouses of the seabed positional acoustic direction-finding system), the use of mobile platforms is proposed. Mobile platforms solve the secrecy problem by means of a pre-planned, episodic change in the spatial position of the seabed infrastructure elements. One of the typical variants of such a platform is a seabed crawler autonomous unmanned underwater vehicle (Howard, R., 2019). The U.S. Navy employs a hybrid type manoeuvrable acoustic direction-finding platform with an aircraft platform - the Aqua-Quad quadcopter. The hydroacoustic beacon network can also be surface-based, which additionally allows the ultra-short baseline's application (hereinafter USBL) and short baseline's application (hereinafter SBL) of underwater positioning systems, which, unlike LBL, ensure positioning continuity. This platform type uses GPS and satellite communications and is able to operate outside the network-centric underwater warfare information layer's coverage.

It is worth noting that the information layer of the underwater network-centric warfare system can be used by both underwater platforms and surface ships, using special hydroacoustic equipment. Such communication and positioning duplication of surface ships is expedient in the conditions of both own and enemy electronic warfare.

So far, the wired data exchange principle is still being applied. For example, DARPA is implementing the development of the Tactical Underwater Network Architecture (Howard, R., 2019), a cable-based system for underwater fibre-optic communication. It is considered that such a system will replace conventional radio communications in overwater space in case the enemy employs electronic warfare. Link 16 standard is used for radio communications between buoys of this system and surface ships and aircraft.

In the Ukrainian Navy of the Armed Forces of Ukraine's shallow water areas of responsibility in the Black and Azov Seas, which occupy the largest part of the water areas, undersea warfare can be conducted by methods and assets that are not available in deep water. It is about the possibility of exchanging data directly through the sea surface, i.e., via a microwave radio channel (Ali F.M., 2020). By combining different physical principles of underwater communication, hybrid communication assets can be created in which the strengths of each method increase the reliability of the hybrid system as a whole (Gage C. P., 2019).

Considering the energy supply perspectives for undersea warfare through the implementation of new physical principles of power generation patented by Lockheed Martin Corporation, in the future, we can expect the implementation of laser technologies for identifying underwater targets, primarily in the interests of the PMO.

Conclusion

Navy of the Armed Forces of Ukraine's training for opposing russia in underwater space requires ‘breaking the current undersea warfare paradigm’. It is necessary to leave in the past the 4-5th technological level armaments and be guided by the network-centric undersea warfare requirements at the 6th technological level armaments and military equipment, which involves the shift to high-precision and autonomous weapons, robotic military equipment platforms.

The main result of our research is a scientific justification that the network-centric principle of forming a battle space and using high-precision weapons will win in the future undersea warfare, including thanks to the network platforms‘manoeuvrability and the unification of the SoS information and sensor layers’ equipment.

Now, watching the developments from the “top” of 2024, we can see the prerequisites for the intellect's victory over the ‘iron’. The kamikaze pilots were in fact the artificial intelligence of high-precision loitering munitions that unexpectedly crushed the US Pacific Fleet's ‘iron’ with lightning speed. Only 70 years have passed and the results of the ‘designers’ modellers", thanks to the 6th technology level technologies, are unexpectedly easily winning over the 5th technology level technologies.

In the undersea network-centric warfare environment conditions, especially in the internal seas and in the coastal ocean area at the exit from the naval base, the modern submarines' vulnerability is expected to increase and, accordingly, their employment effectiveness will decrease. We can expect an increase in interest in technologies for covert deployment of long-range missile launchers on the seabed. Smart mines, as the MUSE operational concept implementation, which involves the deployment of distractions, false targets, and traps, fit well into the network-centric warfare logic.

Recommendations

Considering the Ukraine's experience in the war against russia, it can be stated that the attack on Ukraine was intended, among other things, to seize the military-industrial complex enterprises, without which, due to the russia's technological backlog, it became impossible to produce and maintain aircraft engines, modern avionics, and strategic missiles. This is a typical situation, for example, on the eve of the Second World War (1938), Germany invaded technologically advanced Czechoslovakia, a country with a powerful military-industrial complex at that time, for the same purpose.

In the current geopolitical situation, China openly declares the intention to capture Taiwan, a country with the 6th technological level. The question arises whether it is possible for a country with the 5th technological level to take over a country with the 6th technological level? It is well-known that at the 6th technological level, the victory in the war is won practically without the use of kinetic weapons. The 5th technological level weapons in this war do not give an advantage on the battlefield.

In connection with our study's main content, which is based on the combat experience of gaining victory in the modern war in the Black Sea, we consider it appropriate to recommend reconsidering the possible consequences of an inevitable naval battle in the Taiwan Strait between China's attacking surface ships and autonomous robotic strike (above-water, underwater, air) systems with artificial intelligence that can be developed and manufactured in Taiwan.

Taking into consideration the fundamental changes that have taken place on the battlefield in Ukraine due to the use of unmanned systems with artificial intelligence, we believe that any technologically advanced country can achieve a technological breakthrough in war, regardless of its size, population, military industrial complex resource base, etc. This is proved by Ukraine's combat experience, which uses weapons from the world's leading countries in the war against russia. For example, Taiwan's current technological level already gives reasons to doubt the success of the Chinese Navy's naval operation in the Taiwan Strait.

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