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THE IMPACT OF UNMANNED UNDERWATER VEHICLES TECHNOLOGY ON COMBAT SITUATIONAL AWARENESS

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The domain of underwater has represented for a long time a challenging environment for the implementation of technologies for discovering threats represented by submarines. Passive hydrolocation equipment on board warships have historically been confronted with technological limitations caused not only by the low acoustic imprint of submarine targets but also by a high threshold of false positive alerts due to industrial activities in coastal areas. In addition, the technological constraints and the high costs imposed by the fixed positioning of the active or passive detection sensors allowed submarines to have a wide variety of operating spaces for insidious maneuvering. However, the technological impact of the new combat systems adapted to the submarine environment, mobile and equipped with active sensors in the field of autonomous underwater vehicles, changes this status quo and creates major vulnerabilities on the infallibility of the submarine's secret actions. These new discovery capabilities, combined with intel information processing systems and programs to support decision making will have a significant impact on understanding the operational-strategic situation in the underwater combat environment.

Keywords: undersea warfare; submarines; unmanned underwater vehicles; technological impact.

Unmanned underwater vehicles (UUVs) are an emerging class of autonomous maritime vehicles, with huge potential for transforming the field of Anti-Submarine Warfare (ASW). The technology used by these underwater drones is based on the use of active type sonar for the discovery, classification, identification and tracking of submarines, with the help of mobile platforms arranged at immersion. Autonomous underwater systems represent capabilities intended primarily for shallow-water maritime areas or which have geographical features that make it difficult to use trailed sonar or keel sonar.

The main operational feature of the UUV is represented by the complementary character of the military actions, in relation to the classic aero-naval platforms dedicated to Anti-Submarine Warfare (ships, ASW aircraft, submarines).

The technological progress in the field of military capabilities leads to a conceptual transformation regarding the knowledge of the combat space, mainly in the direction of providing certified, high quality information, available in a short time and with potential in the field of achieving the planned effects at the operational level and strategically. The new operational and strategic environment has the potential to help policy military decision-makers not only determine the threat indexes and provide the optimal tools for responding to the threats of the adversary, but even foresee and prevent the enemy's actions, by using the architecture of new emerging technologies based on general management, advanced management of data and information, communications and artificial intelligence elements.

The future architectural models of knowledge of the employment space have the potential to offer an unprecedented perspective on the capabilities, actions and intentions of the opponent, so that the decision makers will have the opportunity to act proactively and pro-cyclically with a consistent anticipation component. Analyzed together, these capabilities offer a number of characteristics – namely the operational-strategic advantage, the scope, the precision, the persistence, the resilience, the reliability and the operation tempo – which allow the re-thinking of the operational-strategic environment from new perspectives.

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Considerations on the maritime combat space from the perspective of autonomous underwater systems

The analysis and interpretation of the security environment has undergone profound transformations, mainly on three main directions: the accelerated pace of technological innovations, the degradation of the international security environment and the increasing geopolitical tensions. The beginnings of this negative evolution that are hardly predictable at the level of international relations have their origin in the late 1990s and the end of the Cold War. This period was marked by remarkable military technological developments, culminating in the implementation and use of the concept of Network Centric Warfare (NCW) during the Gulf War.

At the conceptual and operational level, this war underpinned the concept of C3I (communications, command, control and information) and made it available to the commanders structured and shared tools regarding the integrated understanding of the employment space on the strategic, operational and tactical levels. The satellite systems allowed the fusion of images from the theater of operations thus opening the perspective of a new approach regarding the optimization of the information cycle.

The network-centric information architecture of the *Network Centric Warfare* has made the lines of separation between operational and strategic level not so clear. The knowledge and interpretation of the characteristics and facts of the combat environment make a translation to the use of unconventional capabilities, in which elements of artificial intelligence acquire an increasingly important position. From this perspective, the introduction in the areas of operations of the autonomous maritime systems represents capabilities that bring not only a new philosophy regarding the conduct of the naval war, but emphasizes the secret and insidious nature of collecting information to obtain the strategic advantages.

The quasi-unanimous feature of the current modern war, from the perspective of introducing in the space of employment of unmanned underwater systems is represented by "merging the data in an architectural concept characterized by distributivism and the creation of an integrated maritime picture"[1]. Through the action of autonomous underwater systems in the emerging information ecosystem of the employment space, as well as by their specific insidious way of action, we can identify significant risks regarding the escalation of the operational situation from the perspective of a conventional approach to the conflict. The risks are associated with the invasive ability to collect information, the secret nature of the actions of the autonomous systems and the limited measures of discovery, identification and recognition of the underwater vehicles starting from their reduced acoustic imprint.

From the starting point of characterizing the autonomous underwater capabilities regarding the advantages of the operation, from the perspective of knowing the battle space, it is necessary to determine precisely the positions in the sailing plan and the intervals for transmitting the information collected from the maritime area[2]. The use of autonomous underwater systems has a considerable influence on reducing the time between the adversary's decision, his action, the discovery of this action and the transmission of relevant information to the decision maker. This factor is determined by reducing the time allocated to the sequences to discover, to orientate, decision making and action in the chain of command and control.

A series of military technologies whose main purpose is the rapid collection of information and data and their processing in a very short time determines the reduction of reaction times on the multiple levels of the military planning process. The implementation of systems specific to artificial intelligence on autonomous underwater systems has led to the processing of large volumes of information, much faster as compared to human operators[3]. The autonomous nature of underwater systems is closely linked to their ability to collect and provide information in the area of interest. An increased autonomy of unmanned underwater systems allows a long presence in the proximity of the opponent's maritime communications lines and the possibility of transmitting an increased flow of information regarding his presence and patrol routes.

The operational picture and strategic ecosystem of nowadays specific to the knowledge of the combat space includes a wide and diverse range of platforms, sensors and capabilities that are connected in the network through complex and highly efficient

communications architectures. The resilience and reliability of autonomous systems refers to the capacity of the technologies used to design and build this equipment regarding the implementation of redundant and robust capabilities for their action in a hostile environment. Autonomous underwater vehicles can be launched in large numbers to form a network of ISR missions.

New systems related to discovery and tracking submarines using capabilities such as autonomous underwater systems are dependent on the development of silent propulsion systems, batteries feed systems, communication systems, and composite construction materials. The achievement of efficient propulsion systems must also be realized from the perspective of increasing the range, the speed of movement through water, the duration of the missions and the preservation of the insidious nature of the actions.

The major challenges associated with using unmanned underwater vehicles come from the constraints of the communications equipment that must be operated in the undersea environment. At this point, autonomous systems must come to the surface of water to transmit the information collected to other warships or observation posts from the coastline. The present studies are focused on the development of technologies that involve the development of submarine antennas that transmit low frequency electromagnetic impulses. Other directions of development include the development of energy sources for the installation of high precision sensors and the optimization of propulsion systems by taking the kinetic energy of the waves.

The complex approach of the threats from the underwater combat space

The active nature of the emerging information ecosystem of operational and strategic level of the knowledge of the employment space includes the capacity of the littoral navies to infiltrate into the territory of the adversary (terrestrial, air or maritime) and to obtain precise information and with high operational potential. All these capabilities are instruments of action on the limit of the interpretation of international law, because they directly challenge the political principles of the sovereignty of the states.

A sub-domain of knowledge of the maritime combat space is that of the underwater environment, which is composed of a conglomerate of concepts, actions, processes and information related to the maritime environment:

- monitoring and evaluation of industrial underwater civilian entities or own military capabilities;
- determining the underwater environmental characteristics of the maritime areas of interest;
- monitoring the maritime transport routes of the merchant fleets.

Autonomous underwater systems can be used in an integrated architecture for detecting submarine threats from a maritime area of interest. The small size of these systems and the ability to act secretly make these capabilities the optimal tools for carrying out research and surveillance missions in an area controlled by the adversary forces. Autonomous underwater systems can be disposed of at mandatory crossing points or in shallow waters, where submarines have a high vulnerability in being detected.

Starting from the current challenges in the field of underwater transmissions regarding the establishment of stable linear encrypted connections between autonomous underwater vehicles and specialized naval platforms in the processing of information collected from the combat space, the optical or low frequency communication fields represent the directions of development in increasing the capabilities of autonomous systems. The maritime environment represents a complex space from the point of view of the propagation of the waves emitted by the underwater sensors mounted on the autonomous vehicles, this bringing with it major constraints on the detect, tracking, identification and classification of the submarines. In addition, the geomorphological anomalies of the maritime space, the variability of the environmental factors and the limitations regarding the operation in coastal regions with shallow water are both concerns for the planners of the operations using the autonomous systems as well as for the designers and manufacturers of this equipment.

The major interest regarding the development of technologies regarding the discovery and tracking of submarine contacts is currently oriented towards obtaining information from the maritime areas under the control of the adversary.

A review of the specialized literature on autonomous underwater systems clearly indicates that the detection, acquisition, integration and analysis of target information must be carried out within the concept of common operating picture (COP), this product being intended for all decision levels. It is of particular importance that the COP be used by all relevant actors in the employment area for the knowledge of the situation and for the exchange of information between their own structures.

Particular attention should be paid to the large volume of information processed and to their collection from various sources, this leading to delays in making useful information products. To overcome these drawbacks, autonomous systems perform their modeling of information processing on artificial intelligence technology, thus achieving interoperability in data sharing and timely dissemination and in an accepted standard format.

The discovery and tracking technology mounted on unmanned underwater vehicles is increasingly being used for disputed areas of action, mandatory crossing points, straits, opponent's ports and its coastal districts.

In the current security analysis of the maritime battle space, these geographical locations become crucial for gaining the strategic advantage and will therefore be increasingly disputed by the relevant regional actors. In this way, the deployment of autonomous underwater vehicles in the space of employment and the transport warships of these capabilities are priorities in the planning and use of effective countermeasures.

The main purpose of autonomous underwater systems is not necessarily a destructive one (based on the concept of combat loading vector) because it is not limited only to missions aimed at neutralizing or intercepting the adverse submarine, but rather one of the ISR domain, mainly oriented towards collecting and transmitting information on the actions of the submarine as a target of interest. The technology used for autonomous underwater vehicles may have dual civilian-military use. Thus, at this moment we have positive results regarding the successful use in scientific fields such as: marine biology, prospecting of the continental shelf resources, monitoring of environmental factors or the fishing industry.

From this perspective, we consider that the dual development of these capabilities is a resource still insufficiently exploited. Developing the civil dimension of autonomous systems capabilities is obviously to the advantage of the military component, if we were to analyze only through the extension of the battery life, the increase of the autonomy or the miniaturization of the navigation sensors.

From the point of view of the expenses related to the research and development of autonomous underwater systems, the sharing of costs between the actors of the national defense system and the civil operators could be a win-win approach for all involved.

The setting up of an underwater traffic monitoring architecture, consisting of hydro-acoustic sensors and autonomous underwater vehicles, has as its main purpose the shortening of the sequences of detection and identification of the threats existing in the maritime areas[4]. The miniaturization of the components of the unmanned underwater vehicles, together with the reduction of the acoustic footprint of this equipment, make these capabilities the optimum instruments to be inserted in an employment space in dispute or in the A2 / AD (anti-access / area-denial) areas.

We can notice that both the high volume of information gathered from the battle space and the quality and the reliability of this information have the potential to tilt the balance of the operational and strategic balance and to cause a rapid escalation of the situation in the theater of operations.

From the perspective of the internal security space, it is considered that a large variety of information and a higher quality of information lead most often to feasible and sustainable decisions. However, there is a risk that the information flow from the command and control architecture will be oversaturated and the essential elements of the evaluation of the employment space will be omitted or analyzed too late to have relevant inputs.

From this perspective, unmanned underwater vehicles equipped with capabilities in the field of artificial intelligence represent the tools that military analysts need to optimize analysis and decision times. Overcoming the bottlenecks at the decision level, arising from the information inflow, can be achieved by introducing the elements of artificial intelligence in the chain of command and control, under the decisional control of the human factors[5].

Finally, the operational and strategic knowledge of the maritime security environment, especially of the underwater space through the introduction of autonomous systems has the potential to provide decision makers with extremely precise information, with a pronounced anticipatory character, especially on the configuration of the concept of operation of the opponent. The development of the opponent's courses of action on the underwater dimension is made much more efficient starting from the attributes offered by the presence for a long time of autonomous underwater vehicles in its maritime areas and the ability offered by this equipment to benefit from the advantage of disruptive technologies.

The specific factors that offer advantages through the view of these technologies are: the systematic action within the A2 / AD areas, the destructive character that autonomous systems can develop, the predictable nature of the actions, the anticipatory nature of the missions of the autonomous vehicles, the dual civil-military nature of the equipment on board, the low level of vulnerability, the secret nature of the actions taken and the reduced acoustic footprint. The deployment into the depth of the adversary territory carried out by the unmanned underwater vehicles represents a specific feature of the autonomous systems that can penetrate the air, sea or land space, but also the command and control architecture of the adversary.

The striking ability available to autonomous underwater vehicles on the adversary's objectives refers to the action of destroying or neutralizing pointed targets, through temporary or systematic actions, in their own or enemy's sectors. Depending on the purpose and objectives pursued, autonomous underwater systems can be configured as hit vectors and can be launched from the boundary of enemy controlled zones. The versatility of autonomous underwater capabilities in the execution of a wide spectrum of missions provides these systems with operational and strategic advantages superior to conventional capabilities, such as warships or submarines.

The action of autonomous maritime systems in the maritime areas is difficult to predict from the perspective of the analysis carried out by the opposing forces. The predictability of the actions of the autonomous systems can be evaluated by the way in which the forces and the capabilities of the enemy can carry out a complex anticipatory analysis. On the other hand, autonomous underwater systems operating in the spectrum of ISR equipped with subsystems from the artificial intelligence domain are capable of carrying out predictive analyzes leading to information products relevant to the knowledge of the security environment at operational or strategic level in a very short time.

The risk is represented by the fact that some of the predictive capabilities of autonomous systems can generate situational risks if the information produced is not properly evaluated by human operators. Complex situations may arise in which the information products offered by artificial intelligence systems generate false threats regarding the actions of the adversary and may ultimately lead to escalation of the security environment based on erroneously interpreted premises.

Autonomous underwater vehicles have the ability to react to different factors in the underwater combat space and to prioritize tasks based on new operating conditions. This ability of autonomous systems, to initiate actions according to the changes in the engagement area is possible due to the contribution of artificial intelligence in carrying out preventive measures without necessarily being predictive. For example, the information received by the autonomous systems from the satellite surveillance systems regarding new actions of the enemy can be defining elements in the modification of the missions or of a new prioritization of them.

The potential of dual use of unmanned underwater systems both for civilian and military purposes can be exploited by achieving common development directions, mainly on the monitoring component of the physical factors of the undersea environment.

The identification of areas of common civil and military interest is an important direction in significantly reducing the R&D costs for a number of components or sensors onboard autonomous underwater vehicles. It is well known the fact that "the reports and information specific to the knowledge of the operational environment are designed to respond to emergency situations or from the perspective of crisis management scenarios"[6].

These information products are developed through collaborative analysis structures that disseminate the final results to civilian and military

decision-makers. Accurate identification of the operational requirements of naval combat missions must be done by analyzing the possibilities of configuring a secure flow of information dissemination in relation to the transfer time and the decision-making process. This process is done by analyzing the elements that define the communications infrastructure, the rate of data transfer, the ability of the underwater systems to position themselves favorably in the maritime battle space.

Perspectives and future guidance

The capabilities represented by the autonomous underwater systems from the perspective of their use for the realization of the integrated maritime image have the potential of an instant warning signal about the danger represented by the adversary forces, achieving a long presence in the maritime area due to operational and strategic interest, substantiating the decision-making processes based on algorithms specific to artificial intelligence.

However, some functions may have the potential to trigger escalation of contextual situations starting from the complexity of understanding the security environment. Autonomous underwater systems contribute to increasing the knowledge of the maritime combat environment. This combat environment is defined by several principles and items which include, among other things, identifying surface and submarine targets, target positions, directions of movement, activity of warships and submarines, load of the merchant vessels, information about weapons and navigational hazards in the area of interest.

We appreciate that the design and development of the use of autonomous underwater systems in the Naval Forces should be mainly oriented towards ASW (Anti-Submarine Warfare) and ISR (Intelligence, Surveillance and Reconnaissance). The need for permanent knowledge of the current situation of the combat space represents an absolute necessity both from the perspective of ensuring the security of the maritime space from a national perspective but also from the collaboration with NATO member states. This is fundamental from the point of view of exercising sovereignty and is essential in meeting the security and security objectives at Alliance level. Obviously this fact is also reflected on some reasons related to the monitoring of the marine environment, the industrial, economic and trade area.

Autonomous underwater systems have the ability to expand the scope of classic naval platforms and to perform a series of missions with minimal cost and without endangering the crews of ships. The accelerated development of technologies for reducing the acoustic footprint of this equipment and the possibility of being launched in the vicinity of the adversary's coastal areas represent serious challenges regarding the detection and identification of the contacts of interest.

To achieve these objectives, the main issue to achieving technical interoperability is given by the inconsistencies between the standards regarding the data typology and the specifications between the military and the civilian environment, this aspect being fundamental in improving the data dissemination capacities between the operators of the autonomous systems.

In our opinion, an important direction for the realization of the inter-institutional information exchange at national level is represented by the capacity of Naval Forces to realize a maritime recognized picture for the areas of responsibility and its sharing to other structures in the national defense system architecture. In this regard, we consider it appropriate "the complementarity of an anti-submarine sensor system that will increase the ability to detect underwater targets"[7]. Such a configuration of the systems will provide much more precise information, regarding the position and motion vectors of underwater targets, of any kind.

In this article we have highlighted how the information collected by the autonomous underwater systems can be used to configure the maritime security environment, with the prospect of considerably improving the operational situation of the warfare space. For a comprehensive understanding of both the information architecture and the content of the information collected from the maritime areas, the commanders from all the structures involved must carry out a detailed analysis of the following aspects:

- identification and integration into a cohesive concept of operation and tasks in which autonomous underwater systems can play a decisive role. In the specific context of the area of responsibility of the Naval Forces, missions from the field of ISR,

ASW or MCM offer obvious advantages from the perspective of using autonomous underwater vehicles;

- developing an integrated conception of using the autonomous systems in terms of streamlining the information flow and making operational and tactical decisions, by integrating specific information structures;
- conducting some opportunity studies applicable to the area of responsibility of the Naval Forces and to the specific of the maritime interests of Romania, regarding the use of underwater systems;
- correlating the needs of developing the use of autonomous underwater vehicles with the general framework for developing and using these capabilities at NATO level;
- identification and use of generally accepted standards for sharing information between several agencies and organizations, as well as developing a typology of data formatting and sharing;
- carrying out an integrated approach to the data and information processed regarding the specific challenges of the submarine environment and analyzes regarding their transfer between the decision-making structures.

In view of the above, in order to maximize the effects of using autonomous systems in the underwater environment, the design of the missions established by the commanders must be analyzed not only from the perspective of the volume of information that these systems can provide but also from the point of view of the achievement of the information flow and especially of their integration in a dedicated center to processing of data collected from the areas of interest.

NOTES:

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