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Introduction

The pace of contemporary technological development is unprecedented. This book was written in 2024 and was preceded by the publishing 'Future Submarine Operating Environment' which dwelled on the big changes ongoing at sea. Nevertheless, a small part of the changes ongoing in the maritime security environment deserve more focus and need special attention. Autonomous Underwater Vehicles (AUVs) are becoming very technologically developed and more and more common as they are implemented in a whole range of missions performed underwater. The rapid expansion of this group of maritime vehicles could be a key distractor that can change the way both underwater and surface warfare are conducted. Only in the last two years has the development in this area been so big that it deserves not a dedicated chapter but a book.

Let's first define what an Autonomous Underwater Vehicles is. The name, in the first place, indicates it is an underwater, submersible, self-propelled vehicle. We need to notice that the word 'vehicle' has a broader meaning than 'ship', but in this case, it excludes ships because ships have a crew, whereas AUVs are unmanned (or uncrewed). In AUVs, an important meaning bears the word 'autonomous', which means that it is not only untethered, but programmed to execute certain tasks without contact with the operator for longer periods. Currently, the definition of this term

is evolving, indicating that the vehicle can respond to the observed environment based on its program.

AUVs are a subset of a bigger group of unmanned (or uncrewed) underwater (or undersea) vehicles (UUVs), which also encompasses remotely operated underwater vehicles (ROVs). Unlike AUVs, ROVs are operated and powered from the surface by an operator, either through an umbilical cord or via remote control. AUVs are also a subcategory of larger group of uncrewed vehicles. Although both terms are often used interchangeably, they carry differences in their meanings. While they both refer to vehicles operated without onboard human crew, AUVs specifically focus on autonomy underwater, meaning they can operate independently.

Nowadays, uncrewed or unmanned vehicles deployed at sea are frequently referred to as naval or maritime drones. While drones typically denote unmanned aerial vehicles (UAVs), emphasizing the absence of onboard crew or pilots, the term is now extended to include uncrewed or unmanned vehicles in marine environments. Unlike in aerial operations where communication is relatively straightforward, establishing communication with underwater drones poses challenges and usually can't be maintained deep underwater. This is the main reason why autonomy is so important for submerged vehicles. Despite this, the terms "maritime" and "naval" drones have become popular in everyday language, although their scope extends far beyond AUVs or UUVs and include all unmanned, both surface and underwater, vehicles.

In summary, an **AUV can be described as a self-propelled, unmanned underwater vehicle designed to execute tasks autonomously. It has the capability to adapt its actions according to environmental cues over extended durations without requiring direct operator intervention.**

An interesting observation is how the definition of AUVs evolved in time. In 2009 AUV was defined as "An autonomous

underwater vehicle, or AUV, is a self-propelled, unmanned, untethered underwater vehicle capable of carrying out simple activities with little or no human supervision…"[1]. In 2021 the definition evolved: "An autonomous underwater vehicle (AUV) is an unmanned submersible vehicle that requires no real-time input or control from a human operator or driver and, therefore, operates autonomously…"[2]. Newer definitions more and more often use words as robotic vehicles or even robots.

It needs to be admitted that the implementation of AUVs we observe nowadays is not enough to be a game changer. It will be relatively cheap, easy to multiply drones containing programs with the ability to learn which will require little human maintenance and operational care. The widespread use of underwater drones may bring many benefits, such as helping to protect sea lines of communication, effectively countering mine threats, delivering reconnaissance from distant areas, aiding against the fog of war, or providing desired information about the maritime environment. On the other hand, if misused, they may become a serious threat to maritime security and could cause serious disturbances in maritime communication. In addition, the spread of AUVs will make, not only the war waged at sea, but maritime operations in general more distant to societies as they will involve less human presence. This will add to the so-called 'maritime blindness' and could make it even much more difficult to find people willing

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1 J.G. Bellingham, *Platforms: Autonomous Underwater Vehicles*, Editors: J.K. Cochran, H.J. Bokuniewicz, P.L. Yager, *Encyclopedia of Ocean Sciences (Third Edition),* Academic Press, 2009, pp. 159–169, https://www.sciencedirect.com/science/ article/pii/B9780128130810007308 (https://doi.org/10.1016/B978-0-12-813081-0.00730-8) (21.03.2024).

2 A. Trembanis, M. Lundine, K. McPherran, *Coastal Mapping and Monitoring*, Editor(s): D. Alderton, S.A. Elias, *Encyclopedia of Geology* (Second Edition), Academic Press, 2021, pp. 251–266 (https://www.sciencedirect.com/science/article/pii/B9780124095489124662), https://doi.org/10.1016/B978-0-12-409548-9.12466-2 (21.03.2024).

to sail the seas. One thing is for sure – once AUVs become ubiquitous there would be no way back. Nowadays, we already observe a few strong trends that empower the prediction of this happening: technological progress, development of AI[3] and cooperation between the AUVs (swarming).

The already visible key change emerging clearly on the horizon is the so-called AI. Artificial intelligence is a key technological enabler. It is capable of learning 24/7 and gaining experience beyond any human capability. In a few days, using simulations or interactions with human operators, AI can excel over the best human operators and find solutions that people would not thought at all. We may expect that AI will soon become omnipresent at all levels: tactical, operational and strategic, and in all branches of life including AUVs. It is expected that AI will dominate future battlespace including the maritime domain. Shortly: maritime forces with AI would overwhelm and completely prevail over forces without. Full stop. The change AI brings seems to be unprecedented in human history and beyond any hitherto available comparison. It could be equivalent to only some abstractive levels of contrast such as swashbuckling against machine guns, horses against fighters, catapults against rockets, or rafts against aircraft carriers.

But nowadays, future warfare is considered not only in terms of implementing AI into weapons but rather integrating it into the decision-making architecture and C2 systems. Although it seems

[3] AI is a commonly recognized abbreviation of "Artificial Intelligence." In this case, however, it is not about intelligence at all but about computer programs or algorithms capable of learning (often described as training or pretraining) on large amounts of statistical data. As of early 2024, AI systems are examples of narrow AI designed to perform specific tasks very well and very fast. AI lacks creativity and the ability to generate new ideas or solutions; it also lacks consciousness and self-awareness. Although contemporary AI has no ethical or moral reasoning, it may be programmed to follow certain guidelines or be forbidden to do certain things.

a distant future where the AI makes a target and kill decisions, we shall assume that AI may soon be used to enhance the systems responsible for processing the battlespace. We may expect that AI could be used as a powerful tool to improve the quality of Battle Management systems and that AI Battle Manager would be something as common as RMP[4] Manager is right now.

Another paradigm shifter that could drastically move the human barriers in conflicts is swarming drones, including AUVs. Underwater drones will be able to communicate with each other[5], and learn from each other with the overarching aim of fulfilling the mission. Swarms will not stop performing the task even if one, some, or most of their members are unable to operate. Moreover, the swarm's tactics may change accordingly to choose the best available option. A direct consequence of swarming would be enabling one operator to control many drones at once. That's a genuine and not-so-distant change.

To show how fast the technological change is, I would use the following example: Had this book been written in 2022, it would have commenced with a comprehensive introduction to AUVs. A long elaboration would state that beneath the surface of our planet's vast oceans lies a mysterious and captivating world. This world remains largely unknown, uncharted, and untouched by human exploration. For centuries, mankind has been lured by the secrets held within these depths, eager to unlock their mysteries and harness their potential.

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4 RMP – Recognised Maritime Picture.

5 NATO Centre for Maritime Research and Experimentation developed in 2017 an underwater communication protocol called JANUS that become a NATO Standard. See more: NATO CMRE, *JANUS, the CMRE underwater communication protocol, becomes a NATO Standard*, https://www.cmre.nato.int/rockstories-blog-display/398-janus-the-cmre-underwater-communication-protocol-becomes-a-nato-standard (20.03.2024).