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ADVANTAGES AND DISADVANTAGES OF SURFACE ROBOTS IN VARIOUS FIELDS OF APPLICATION

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The article examines the main advantages and disadvantages of surface robots used in scientific, industrial, civilian, and military domains. The study highlights benefits such as operational safety, cost-effectiveness, autonomy, and design features. It also addresses key limitations, including technical challenges, communication issues, legal regulations, and financial barriers. This analysis provides a comprehensive understanding of the potential and limitations of unmanned surface vehicles as an advanced technological solution.

Key words: surface robots, water logistics, advantages and disadvantages, scientific research, monitoring

ПЕРЕВАГИ ТА НЕДОЛІКИ НАДВОДНИХ РОБОТИЗОВАНИХ СИСТЕМ У СУЧАСНИХ СФЕРАХ ЗАСТОСУВАННЯ

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У статті розглянуто основні переваги та недоліки використання надводних роботів у різних сферах: науковій, промисловій, цивільній та військовій. Виокремлено переваги, пов’язані з безпекою, економічністю, автономністю та конструктивними особливостями. Також проаналізовано ключові недоліки, включно з технічними складнощами, проблемами зв’язку, правовим регулюванням та фінансовими бар’єрами. Представлений аналіз дозволяє сформувати уявлення про потенціал та обмеження використання надводних роботів.

Ключові слова: надводні роботи, водна логістика, переваги та недоліки, наукові дослідження, моніторинг.

RELEVANCE OF THE WORK. In era of modern technological advancements and requirements faced by scientific, military, and industrial sectors, surface robots are gaining increasing popularity as a versatile tool for performing various tasks. Their ability to operate in challenging conditions, ensure autonomy, and reduce human factors opens new possibilities for monitoring water bodies, conducting research, and ensuring security. Surface robots are becoming important participants not only in rescue and military operations but also in fields such as ecology, climate change research, and natural resource management. The use of these technologies significantly increases task efficiency, reduces costs and risks, and ensures accuracy in data collection and processing.

INTRODUCTION. Surface robots are gaining increasing importance in various fields due to their ability to perform complex tasks and operate in conditions where human presence is undesirable or dangerous. An important part of their development and implementation is understanding both their advantages and disadvantages. Considering these aspects is necessary for creating effective and safe systems, as well as minimizing risks and improving the use of surface robots in various conditions. This article will examine the main advantages and disadvantages of such technologies, allowing for an assessment of their potential and identification of key factors for successful implementation.

MATERIALS AND RESEARCH RESULTS. One of the main advantages of surface robots is their ability to perform dangerous missions without involving human crews. In particular, when clearing water areas of mines, protecting coastal zones, or operating in adverse weather conditions, these devices help avoid risks to human lives. Additionally, such devices can be used to target water-based objectives, which is of particular importance in the context of modern military conflicts [1].

The use of surface robots significantly reduces economic costs. The absence of crew members eliminates the need for life support systems, reduces fuel costs, technical maintenance and repair expenses for equipment and the device itself, as well as employee salaries [2].

Surface robots enable the implementation of long-term tasks since they can remain in aquatic environments much longer than vessels with human crews. The absence of human factors—such as the need for sleep, food, etc.—provides the possibility of continuous operation for days, weeks, and even months or years. Furthermore, such devices can function in harsher weather conditions compared to conventional vessels since there is no need to consider crew comfort [3].

In the absence of a crew and life support systems, surface robots can have a more aerodynamic design, making them faster, more maneuverable, and smaller in size. These characteristics make controlling such devices easier, allow for installation of more equipment necessary for achieving set objectives, and enable access to hard-to-reach places [4].

Surface robots play a key role in modernizing the field of maritime transportation and logistics, ensuring high levels of productivity and cost reduction. Thanks to autonomous operation without the need for a crew, these devices significantly reduce maintenance costs and eliminate risks to personnel health and life. Equipped with intelligent navigation and communication systems, they can effectively navigate maritime routes, avoid obstacles, and build optimal movement trajectories, positively impacting fuel economy and reducing harmful emissions into the environment. Additionally, surface robots can perform functions of remote monitoring of vessel technical conditions, cargo inspection, and surveillance of port facilities, contributing to increased safety of maritime operations [5].

Modern surface robots demonstrate significant environmental advantages compared to traditional vessels. Due to their compact size and lightweight construction, they consume less fuel, leading to reduced greenhouse gas emissions. Many models are equipped with alternative energy sources, such as wind and solar installations, allowing them to operate for extended periods without refueling, reducing dependence on fossil fuels. Furthermore, the absence of the need to transport fuel or other hazardous materials reduces the risk of environmental disasters, such as oil spills. These characteristics make surface robots more environmentally safe and contribute to the sustainable development of maritime operations [5].

However, like any technical means, surface robots have certain disadvantages. The first is the constant exposure to moisture, salt and fresh water, and temperature fluctuations, which creates specific requirements for protecting electronic and mechanical elements. Water corrosion can quickly damage unprotected elements, significantly reducing their service life and that of the entire system. The need to create waterproof protection significantly increases production costs and adds complexity to the device's construction. At the same time, the requirement for complete sealing of all components creates obstacles for quick repairs and scheduled maintenance, causing even minor technical problems to lead to interruptions in the robot's operation [5].

Another disadvantage of surface robots is the vulnerability of communication and navigation systems during cyber attacks or electronic countermeasures. During mission execution, navigation problems may arise due to interception of control over the device or replacement of navigation data, which can not only disrupt the task but also potentially make the device a dangerous tool against those who use it. Therefore, creating an effective security system for communication channels and software becomes critically necessary, although technically extremely complex [6].

The legislative framework regarding surface robots is still forming, and there is a need for standardized rules for their safe operation. Regulatory aspects regarding licensing, insurance mechanisms, legal responsibility, and safety certification require comprehensive regulatory settlement for facilitating full-scale integration into maritime operational systems. The lack of approved legal norms may become a restraining factor for the use of surface robots [7].

Despite the fact that surface robots provide savings by reducing operational costs, initial investments in their acquisition, repair, and modernization can be significant. The cost of modern technologies, namely sensors, communication systems, and artificial intelligence integration, additionally increases the overall cost of the robot. Price affordability may be a limiting factor, especially for clients or organizations with limited budgets [7].

Another significant limitation of surface robots is their limited payload capacity. Due to compact sizes and design features, these devices cannot transport heavy equipment or large volumes of cargo, limiting their application in certain areas, such as transporting significant amounts of materials. This limitation needs to be considered when planning missions and determining tasks that can be effectively performed using surface robots [7].

The complexity of integration with existing infrastructure and management systems is a serious challenge for the widespread implementation of surface robots in navigation. Most existing ports, navigation hubs, and logistics facilities are designed to service traditional vessels with human crews. They are not adapted to autonomous devices that require special conditions for mooring, recharging, cargo transfer, or data reading. Additionally, existing management and monitoring systems often do not support communication protocols used by surface robots. This leads to incompatibility at the level of software and communication channels, complicating centralized management of unmanned device fleets. Overcoming these problems requires modernization of infrastructure, including installation of appropriate terminals, automated docks, charging stations, as well as integration of unified information systems. All this requires significant financial and technical resources, which may become a restraining factor for many countries and companies, especially in conditions of limited budget or technical backwardness of the region [8].

CONCLUSIONS**.** Surface robots play an increasingly significant role in modern scientific, industrial, and security fields due to their autonomy, environmental friendliness, and ability to effectively operate in difficult conditions without human risk. They demonstrate a wide spectrum of advantages—from reducing costs and minimizing human factors to increasing accuracy and duration of task execution. Along with this, it is important to consider technical and regulatory limitations associated with their operation, among which the influence of the aquatic environment, cyber threats, high technology costs, and limited payload capacity should be especially highlighted. Further development of this field requires improvement of designs, enhancement of security system reliability, and formation of a unified legal framework that will allow for full integration of surface robots into various spheres of human activity.

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