УДК 623.746:355.415

Oleksandr Tokar, Serhii Cherkashyn

THE ROLE OF UNMANNED GROUND VEHICLES IN THE LOGISTICS SUPPORT OF AIR DEFENSE UNITS

Анотація. *Повномасштабна російсько-Українська війна зумовила суттєве ускладнення логістичного забезпечення підрозділів протиповітряної оборони Сухопутних військ Збройних Сил України та підвищила вимоги до безперервності й оперативності постачання в умовах інтенсивного бойового впливу. Досліджено перспективи застосування роботизованих наземних систем як одного з напрямів удосконалення військової логістики, підвищення її ефективності та стійкості. Розглянуто основні завдання, які можуть виконувати такі системи, зокрема транспортування боєприпасів і матеріально-технічних засобів, дистанційне обстеження маршрутів, моніторинг логістичних процесів, евакуацію пошкодженої техніки та доставку медичних засобів. Визначено ключові технічні й експлуатаційні характеристики, від яких залежить ефективність роботизованих платформ, серед яких вантажопідйомність, прохідність, енергетична автономність, надійність каналів зв'язку, стійкість до впливу засобів радіоелектронної боротьби та ремонтопридатність. Окреслено основні технічні обмеження й організаційні виклики впровадження роботизованих систем, пов'язані з підготовкою персоналу, технічним обслуговуванням, захистом інформації та інтеграцією з наявними системами управління логістикою. Обґрунтовано доцільність поетапного впровадження роботизованих наземних систем як складової військової логістики, що сприятиме зменшенню ризиків для особового складу, підвищенню гнучкості логістичних процесів і забезпеченню безперервності постачання підрозділів протиповітряної оборони.*

Ключові слова: *роботизовані наземні системи, логістичне забезпечення, підрозділи протиповітряної оборони, військова логістика, безпілотні наземні транспортні засоби.*

Abstract. *The full-scale Russian-Ukrainian war has significantly complicated the logistics support of air defense units of the Ground Forces of the Armed Forces of Ukraine and increased the requirements for the continuity and timeliness of supply under conditions of intense combat operations. The paper examines the prospects for employing robotic ground systems as a means of improving military logistics, enhancing its efficiency and resilience. The main tasks that these systems can perform are considered, including the transportation of ammunition and materiel, remote route inspection, logistics process monitoring, recovery of damaged equipment, and delivery of medical supplies. The key technical and operational characteristics determining the effectiveness of robotic platforms are identified, including payload capacity, cross-country mobility, energy autonomy, communication reliability, resistance to electronic warfare, and maintainability. The main technical limitations and organizational challenges associated with the implementation of robotic systems are outlined, including personnel training, maintenance, information security, and integration with existing logistics management systems. The feasibility of gradually integrating robotic ground systems into military logistics is substantiated. Such integration can help reduce risks to personnel, increase the flexibility of logistics processes, and ensure continuity of supply to air defense units.*

Keywords: *robotic ground systems, logistics support, air defense units, military logistics, unmanned ground vehicles.*

The full-scale Russian-Ukrainian war has fundamentally transformed the conditions of military operations and logistics support. The widespread use of unmanned aerial vehicles, precision-guided weapons, electronic warfare systems, and continuous reconnaissance has significantly

complicated the movement of personnel, ammunition, fuel, spare parts, and other material resources. Under these conditions, ensuring the continuity of logistics support is an important prerequisite for maintaining the combat readiness of air defense units of the Ground Forces of the Armed Forces of Ukraine.

One promising direction for improving logistics processes is the introduction of robotic ground systems (RGS), which enable selected transportation, monitoring, equipment recovery, and auxiliary support tasks to be performed with reduced direct exposure of personnel to hazardous environments. The relevance of this approach is determined by the need to improve the resilience, flexibility, and efficiency of military logistics under conditions of high-intensity warfare. Robotic ground systems are wheeled or tracked platforms designed to perform assigned tasks through remote control, partial automation, or autonomous operation. Depending on their design and intended purpose, these systems can be fitted with cargo-carrying units, navigation systems, electro-optical sensors, communication devices, robotic manipulators, and task-specific equipment modules. Their principal functions include transporting ammunition, batteries, communication equipment, spare parts, food, water, and other supplies; delivering resources to difficult-to-access areas; evacuating damaged equipment; transporting medical supplies; and conducting remote inspections of routes and infrastructure.

The effectiveness of such systems depends on payload capacity, mobility, operating range, energy autonomy, communication reliability, and resistance to environmental interference. Consequently, selecting an appropriate platform requires an assessment of operational needs and actual employment conditions rather than relying exclusively on its technological sophistication. A key area of application is the transportation of ammunition and other material resources necessary to sustain air defense operations. Units may operate in dispersed formations, frequently change positions, and experience restricted access to conventional transport routes. In these circumstances, robotic platforms can perform selected supply tasks, reduce the physical workload of personnel, and limit their exposure to hazardous conditions. Modular designs can further increase operational flexibility by enabling a single platform to accommodate different cargo types and support requirements. Nevertheless, robotic transportation should be integrated into the existing logistics system rather than considered a complete replacement for conventional transport. Appropriate procedures are required for cargo loading, securing, accounting, delivery confirmation, technical inspection, and the safe handling of ammunition and sensitive equipment.

Another important advantage of robotic ground systems is their potential to operate on damaged roads, uneven terrain, and in areas with restricted accessibility. Tracked platforms may provide improved mobility on certain types of soft ground, whereas wheeled systems can offer greater efficiency on suitable surfaces. The choice of chassis must account for terrain conditions, payload, energy consumption, maintainability, and the intended function. Mine contamination, physical obstacles, adverse weather, and communication failures may nevertheless restrict their employment. Therefore, reliable navigation, operator training, technical support, and procedures for responding to system failures remain essential.

Robotic platforms equipped with optical, thermal, and other sensors can also support logistics monitoring and information collection. They may facilitate remote inspections, assessment of route accessibility, observation of cargo movement, and transmission of information to logistics personnel. Integration with digital management systems can improve inventory accountability, delivery tracking, and coordination between supply elements and supported units. However, logistical monitoring must be distinguished from air surveillance: detecting, classifying, and tracking aerial targets requires specialized equipment, validated processing capabilities, and integration with authorized command-and-control systems. Despite their potential, robotic ground systems have several

limitations. Battery-powered platforms have restricted operating endurance, which depends on payload, terrain, weather, and onboard equipment consumption. Navigation and communication may be affected by electronic warfare, interference, or equipment malfunction. Restrictions in mobility and load-carrying capacity may limit the ability of robotic platforms to perform tasks beyond their intended capabilities. Furthermore, the total cost of ownership includes not only procurement but also batteries, spare parts, maintenance, software updates, operator training, and repair infrastructure.

Successful implementation of robotic ground systems requires clear responsibilities for operation, maintenance, information security, and cargo accountability. Digital integration must ensure reliable data exchange and operational continuity during communication failures. Further development should focus on autonomy, energy efficiency, modularity, and integration with digital logistics systems. The use of data analytics can enhance resource demand prediction and maintenance scheduling; however, human oversight, robust cybersecurity measures, and clear accountability must be maintained.

Robotic ground systems can improve the logistics support of air defense units by automating transportation, monitoring, equipment recovery, and medical supply delivery while reducing risks to personnel. Their effectiveness depends on technical reliability, mobility, energy autonomy, communication resilience, and maintainability. Therefore, their gradual integration into military logistics should be supported by operational testing, personnel training, and standardized procedures.

References:

1. European Defence Agency. The EDA Action Plan on Autonomous Systems: Preparing the Autonomous Systems of the Future. 2024. DOI: 10.2836/6119972.

2. U.S. Army. Technologies to Sustain the Army of 2025 and Beyond. URL: https://www.army.mil/article/132473/technologies_to_sustain_the_army_of_2025_and_beyond.

3. European Defence Agency. Call for Contributions: Market Research on Innovative Unmanned Solutions for Military Logistics. 26 February 2024. URL: https://www.eda.europa.eu/news-and-events/news/2024/02/26/call-for-contributions-market-research-on-innovative-unmanned-solutions-for-military-logistics.

4. Defense Logistics Agency. Safe Operation of Mobile Unmanned Ground Vehicle (UGV) Systems. Test Operations Procedure TOP-02-2-541. Revision A, 4 September 2024. URL: https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=276376.

Токар Олександр Анатолійович *– старший викладач кафедри тактики військ протиповітряної оборони Сухопутних військ факультету протиповітряної оборони Сухопутних військ та інших складових Сил оборони України Харківського національного університету Повітряних Сил імені Івана Кожедуба, м. Харків вул. Сумська 77/79, інд. 61023, e-mail:sash.2015@ukr.net, ORCID: https://orcid.org/0000-0003-4889-7550*

Черкашин Сергій Володимирович *– старший викладач кафедри тактики військ протиповітряної оборони Сухопутних військ факультету протиповітряної оборони Сухопутних військ та інших складових Сил оборони України Харківського національного університету Повітряних Сил імені Івана Кожедуба, м. Харків вул. Сумська 77/79, м. Харків вул. Сумська 77/79, інд. 61023, e-mail: cherkashynppo@gmail.com, ORCID: https://orcid.org/0009-0002-6940-3863*

Oleksandr Tokar *– Senior Lecturer, Department of Ground Forces Air Defense Tactics, Faculty of Air Defense of the Ground Forces and Other Components of the Defense Forces of Ukraine, Ivan Kozhedub Kharkiv National Air Force University, Kharkiv, 77/79*

Sumska Street, Ind. 61023, e-mail:sash.2015@ukr.net, ORCID: https://orcid.org/0000-0003-4889-7550

Serhii Cherkashyn *– Senior Lecturer, Department of Ground Forces Air Defense Tactics, Faculty of Air Defense of the Ground Forces and Other Components of the Defense Forces of Ukraine, Ivan Kozhedub Kharkiv National Air Force University, Kharkiv, 77/79 Sumska Street, Ind. 61023, e-mail: cherkashynppo@gmail.com, ORCID: https://orcid.org/0009-0002-6940-3863*