ПИТАННЯ РОЗВИТКУ ЛОГІСТИЧНОГО ЗАБЕЗПЕЧЕННЯ РОДІВ ВІЙСЬК ПОВІТРЯНИХ СИЛ ЗБРОЙНИХ СИЛ УКРАЇНИ

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PECULIARITIES OF DEVELOPMENT OF LOGISTIC SUPPORT FOR USING OF UNMANNED AERIAL VEHICLES

The main aim of the report is creation an unified theory of logistics of the Air Forces of the Armed Forces of Ukraine based on the existing theories of armament and the logistics of the Armed Forces, the general laws and determined trends, principles, forms and methods of the use of the logistics of the Air Forces of the Armed Forces of Ukraine and impact Unmanned Aerial Vehicles (UAV) on this theory. Based on the information analysis on critical UAV maintenance tasks including tasks unique to UAV operations, and the facilities and personnel involved in maintenance, the issues of UAV maintenance were grouped into three categories.

The objective function of the logistics system of the Air Forces of the Armed Forces of Ukraine is formulated, which is to achieve compliance of the capabilities of this system with the predicted volume of tasks of the logistics given the use of UAV. In order to implement this compliance it is necessary to ensure the convergence of requirements and capabilities at all levels of logistics management.

The assessment of the functioning of the Air Forces logistics system of the Armed Forces of Ukraine is proposed on the basis of the stated views on the logistics theory of the Air Forces of the Armed Forces of Ukraine by assessing the set of real capabilities of each subsystem that is the part of its structure and system as a whole.

At the same time, the assessment of the quality of the logistic support of the military units (formations) of the Air Forces of the Armed Forces of Ukraine should be related to the level of implementation of the potential capabilities of the logistics system when solving problems of each subsystem at the stages of combat training, unblocking and operational deployment, preparation and conduct of operations (combat actions), restoration of combat capability of troops (forces).

Keywords – *Unmanned Aerial Vehicles (UAV), logistics of the Air Forces of the Armed Forces of Ukraine, logistic system of the Air Forces of the Armed Forces of Ukraine, logistics*

Introduction

The organizational structure of the logistics management bodies, the list of necessary assets of logistics, their functional duties and tasks were basically determined in pursuance of the measures of the State Program for the Development of the Armed Forces of Ukraine up to 2020 (approved by the Decree of the President of Ukraine - Supreme Commander-in-Chief of the Armed Forces of Ukraine dated March 22, 2017, No. 73/2017) concerning the creation of a unified logistics system of the Armed Forces of Ukraine as a result of the joint work of the General Staff of the Armed Forces of Ukraine and the interested military authorities.

The maintenance peculiarities of UAV while developing the perspective logistics system of the Armed Forces of Ukraine (UAF) related to the needs to take into account that UAV operators must ensure the reliability of an entire system that comprises the vehicle, the ground station, and communication equipment. It is due to that the accident rate for UAVs is higher than for conventional aircraft. A significant proportion of these accidents are associated with

human error and it will be necessary to understand the human factors associated with UAV.

Throughout the history of aviation, human error has presented a significant challenge to the operation of manned aircraft [1]. Given the fact that maintenance and ground support activities appear to be responsible for a growing proportion of airline accidents [2], this human factor element will be a critically important part of UAV operations. To enable the operation of UAVs in UAF it is necessary to understand the human factors of unmanned aviation and to identify human factors that will apply in the maintenance of UAV systems.

The perspective logistics system of the Armed Forces of Ukraine (UAF) provides for vertical division: planning (determination and planning of meeting troops' requirements) and executive (maintenance of necessary material resources and provision of troops with material resources and services). Therefore, a set of measures are planned to be taken in the Air Forces (AF) of the UAF in order to improve the logistic system by creating a planning and executive authority for managing logistics, providing air commanders with satisfying functions for providing logistical facilities, forming airbases (with UAV) for the provision of aviation brigades, transfer of certain military units of logistics to the air commands.

The current integrated logistic system of the AF of the UAF is a set of combined logistic command units of the command of the AF of the UAF, departments of logistics of air commands, services and units of the logistics and combat service support of military units (subdivisions) with subordinated assets of logistics, the number of which is determined by the combat composition, structure, tasks of the military units (subunits) of the AF of Ukraine and intended for solving the tasks of planning and the logistical support of the forces (forces), as well as the implementation of logistics measures of the military units (divisions) of the AF of Ukraine in their daily activities, during combat training, mobilization, operational deployment and combat readiness, preparation and conduct of hostilities , restoration of combat capability of military units (subunits) [3].

To provide the UAV operation it's necessary to understand the features of combat use and logistic of UAVs. At the same time the maintenance like a kind of logistic is the activities which are performed on the land before and after the UAV flying for providing of successful and safely use of UAV. According to this general definition the UAVs logistic consists of storage, fueling, pre-flying check, repair and software update. The maintenance activities of UAVs also contain the use of UAV transporter vehicle and UAV land control station [1]. As it follows from the analysis of accidents in the USA Army [2] 32 % of accidents are the results of human error and 45 % of accidents are the results of failures of technical means (either singly or in combination with other factors). So the reliability of UAVs logistic system is essentially more important than in case of manned aerial vehicles. Independent of the features of combat use and logistic of UAVs they can be integrated in the Informational Support System for Technical State Control of Military Equipment [4].

The logistic system of the AF of the UAF is designed to fulfill the tasks of logistics of military units (subunits) in the conduct of operations (combat actions) under any conditions of the situation.

The objective function of the logistic system of the AF of the UAF is formulated as the achievement of the compliance of the capabilities of this system with the predicted volume of tasks of logistics. In order to implement this condition it is necessary to ensure that the requirements and capabilities are consistent across all levels of logistic management (including UAV management). Deviations from these conditions must be compensated within the set limits by the reserve of opportunities at each level of the hierarchy. In order to achieve this goal the logistic system of the higher level, which is the logistics of the command of the AF of the UAF, must have a reserve of abilities to influence the lower level in case of critical situations appear. In this case, the scope and timing of the measures in the interests of air commands and units (subunits) of the UAF are determined.

Analysis of recent research and publications

The analysis of the logistic support systems of the leading countries of the world, NATO-member states (partner countries) [5-8] was carried out to determine the main views on the logistics theory of the AF of the UAF, and logistic systems of the UAF [9] has been carried out and all elements of this system which participate in the combat service support of operations (combat actions) of military units (subunits) were examined. The approach of the decomposition of the logistic system of the AF of the UAF allowed revealing the influence of each element on the implementation of its logistics functions.

Considering the relevance and importance of using UAV during combat operations the main factors affecting accident rate for UAVs were analyzed and they were arranged in three sections. Hardware issues are human factors that relate to the interaction of maintenance personnel with the physical structures of the UAV system. Software/documentation issues concern the interaction of maintenance personnel with computer systems and written documentation. The last section deals with personnel issues including the skill levels of maintenance staff [1].

The optimal composition and logistics structure of the AF of the UAF, improvement of forms and methods of logistic support, development of logistics' principles, management and interaction methods elaboration contributed to the successful solution of tasks. At the same time, the subsystem of the technical support of the AF of the UAF (under the nomenclature of logistics) requires to be improved, as at present stage separate technical support tasks are organized within different chains of command (there is no single authority who organizes the implementation of all kinds of logistics technical support).

The development of the theoretical elaboration of the issues of logistic support for conducting operations (combat actions) is based on solving logistic problems of the UAF, namely the search for ways to resolve the discrepancy between the desirable and the actual state of logistics, which is considered in the publications of Romanchenko I.S. [10, 13], Khazanovich O.I. [10],

Tarasenko A.V. [11], Shuenkin V.O. [12, 13], Rolin I.F. [14], Servatyuk V.M. [15] and Krizhny A.V. [16].

In today's conditions of conducting operations (combat actions) existing separately the theory of armament and the theory of the rear services of the AF, as components of military science, lose their functional purpose as partial theories.

Taking into consideration modern forms and methods of conducting operations (combat actions), as well as requirements for forming a unified logistics system of the UAF and logistics, created management bodies, forces and means of logistic support of military units (subunits) of the UAF, maintenance peculiarities of UAV the purpose of the report is to define the main provisions of the new the unified logistic theory of the AF of the UAF. In this context the basis of the unified theory of logistics is the following methodologies: the methodology of system logistic analysis; the methodology of the cybernetic approach to the management of logistics systems; the methodology of operations research and the forecasting methodology.

Presentation of the main research material

On the basis of the analysis of the logistic support of the AF of the leading countries of the world and NATO member-states (partner countries) [5-8], certain types of activities, requirements and tasks of logistic support [3], created logistic structures of military units (subunits) of the UAF, scientific methods of research of logistics, a unified theory of logistics of the AF of the UAF is proposed, which includes the following main components:

the conceptual apparatus and the empirical basis of logistics of the AF of the UAF, which are based on the forms of scientific knowledge and contain scientific positions and results, as well as the mechanism of their implementation;

initial conceptual provisions according to the types of logistics activities of the UAF, which consider and provide the development of the necessary methods for calculating the needs of forces and assets of logistics of the AF of the UAF;

the main provisions for the preparation of the logistics infrastructure for the accumulation, separation and conservation of material resources, the use and replenishment of stocks, the operation of weapons and military equipment; increase of efficiency of logistics by activities;

rules of logical conclusions which are based on the generalization of experience of creation and functioning of the logistics management bodies of the Armed Forces of the leading countries of the world and NATO member-states (partner countries), determine the directions of the long-term development of logistic support of military units (subunits) of the UAF providing the ability to integrate logistics systems while performing compliant operations.

That is, as for its structure, the theory of logistics of the AF of the UAF is an internally differentiated integral system of knowledge about material, transport, evacuation, information and financial flow processes according to types of activity, which characterizes the logical dependence on some elements from others, the derivation of the content of the theory of logistics from a certain set of statements and concepts according to the defined logical and methodological principles and rules.

The analysis of the logistic support of military units (subunits) of the UAF indicates the availability of approaches as for the use of the proposed logistics theory.

The main of these approaches are the following:

solving tasks according to the types of activity of logistics of the AF during the conduct of operations (combat actions) in the established scope of tasks and in interaction with the logistics systems of the Land Forces of the UAF, the Naval Forces of the UAF, other military formations and law-enforcement agencies of special assignment, defence industry, and other branches of the national economy of Ukraine;

logistic maintenance of high autonomy of conducting operations (combat actions) of military units (subunits) of the UAF;

maintenance of high maneuverability and mobility of military units (subunits) of the UAF in the conduct of operations (combat operations), which is provided by resettlement, transfer and promotion of military units (subdivisions) of the Airborne, development of the aerodrome network;

creation and improvement of the logistic system of the AF of the UAF on the basis of a functional integrated system of logistics of the UAF;

the capacity of the logistic system of the AF of the UAF to conduct operations in the operational groups of the Army (forces) of the UAF;

achievement of high efficiency and functionality of logistic processes and their compatibility with the NATO logistics system by applying the relevant NATO standards in the activities of the AF of the UAF [17];

improvement the UAV maintenance representing new challenges for maintenance personnel. These tasks include transport and assembly of the vehicle and associated systems, and pre-flight ground tests necessitated by the assembly of the aircraft at the flight location.

The basis of these approaches is the modular and territorial principles of logistics constructing the infrastructure for the provision of military units (subunits) of the UAF. In this case, the territorial system of logistics of the AF is represented by a multilevel hierarchical structure, the basis of which is logistics bodies. Organizationally it includes the logistic bodies of the Command of the UAF, air commands, and military units of the AF. The logistic structure of the AF of the UAF will be brought in line with the typical structure of the logistics management bodies in all services of the UAF and the logistic units of the strategic level.

At the management of logistic of units equipped with UAV it's necessary to consider:

- Assembling. Tactical and operational UAVs, as a rule, is disassembled after the flying for transportation and storage. The frequent turning on and turning out of UAV electrical circuits is the factor of special dangerous. It can increase the probability of damages and breakages and probability of maintenance error.

- Peculiar elements of UAV. UAV system can contains unique components like launching catapult, autonomous landing system, system for flying finish (landing parachute breaks out, turning on landing engine).
- A requirement for battery maintenance. Batteries are the reason of a great number of failures of onboard and land elements of UAV system.
- Composite materials. A lot of composite materials are used in different elements of UAV. The repair of these materials needs special experience and special equipment for work with insecure materials.
- Repair of UAV by its maker. The small dimension of components and modularity design of UAV allow to send the damaged components to the UAV maker for the repair.
- There isn't any statistics about modes and speed of UAV components failures. The tactical UAV makers don't show any information about the modes of failures of UAV components and its term of service or failure frequency. At the absence of information about the of UAV components the maintenance program for reliability support can be created.
- Accounting of UAV operation activity. As a rule, UAV haven't onboard meter for accounting of flying time or engine operation time. If this information don't write by UAV land control station the UAV flying time must be account manually for management maintenance and planning of repair.
- Absence of numbers of UAV components. The majority of UAV components haven't number of each components which can be recoverable. If we don't know the history of use maintenance and recovering such UAV components the probability of error in maintenance is increase.
- Non-standard moving system. Last time the new scientific technologies are used in UAV. These technologies are used in the fueling system, system of solar powering and electric motors. It needs the additional information about the maintenance of the UAV components based on the new scientific technologies.
- Fuel blending. Some types of UAV needs fuel blending. The blending is performed by operator without special metering. So the dangerous for operator health or UAV flying can be caused by human error.
- Insufficient quality of operation and maintenance documentation. It was shown that the majority of UAV are used without any maintenance documentation. If UAV are delivered with the UAV operation and maintenance documentation it don't correspond to the general system. Moreover, the operation and maintenance documentation has some unclear procedures, in particular documentation of Fault Isolation Manual [1, 2].

Methodologically, the central role of the formation of the proposed logistics theory of the AF of the UAF is to determine the patterns, trends, principles, forms and methods of logistic for conducting operations (combat actions) of military units (subunits) of the AF of the UAF, which are formed within the framework of the theory of logistics and relate to logistic support.

Analysis of the development of logistic support of the AF of the UAF allows to identify patterns that reflect the stable links of the logistics system of the AF of the UAF with the development of the branches of the national economy of Ukraine, the infrastructure of logistics and the transport system of the country. That is, for the logistic system of the AF of the UAF the dependence of the quality of the preparation, conduct and outcome of the operation (combat actions) on the state and capabilities of the logistic support system is inherent.

The complexity and interconnection of logistic support measures, namely, a clear and transparent logistic support management system (material, transport, evacuation, information and financial flows management) in the logistic system of the AF of the UAF give rise to the second regularity of its construction and functioning, which is expressed in a unity of infrastructure support of logistics of the AF of the UAF, which is an integral part of the engineering and infrastructure support of the UAF, both stationary and mobile, for the purpose of measures of their vitality. Creation within the framework of a single logistic space of the UAF logistics system of the UAF will allow fulfilling the requirements of logistics of the AF of the UAF in accordance with the modular and territorial principle of construction of the logistics infrastructure.

The next regularity of logistic support is the centralization of management and the decentralization of the implementation of the tasks of using the logistic system of the AF of the UAF provided that the assets of logistic support for conducting operations (combat actions) are sufficient.

Knowledge of the laws allows us to understand the operation and properties of the logistics system and to form more adequate decision-making model. In the future, the patterns are manifested in the form of trends that determine the existence and improvement of the logistics system of the AF of the UAF through the interaction of this system with the infrastructure of logistics, transport system and branches of the national economy of Ukraine.

On the basis of an analysis of the organization of the operation and development of logistics systems of NATO member-states (partner countries), in particular by examining the logistical support of the troops, it is possible to identify a number of stable tendencies that are related by the limitation of most resources, the high destructive ability of enemy weapons, and the speed of conducting operations (combat actions). The tendencies, which belong to the logistics of the AF of the UAF, are the following:

centralization of planning and organization of logistics at the level of logistics Command of the UAF;

the dependence of the organization and management of logistic support on the structure of the

AF of the UAF, the material base and conditions for the implementation of logistic support;

implementation of the territorial system of providing military units (subunits) regardless of their belonging to one or another service of the UAF;

maintaining the proportionality and optimum correlation in the organization of logistic support of the AF of the UAF in the general system of logistics of the UAF;

the unity of organizational and methodological foundations (organizational and information support, analysis, planning, control) of the logistic system of the AF of the UAF at all levels of logistic support;

compatibility of logistic assets of interacting military units (subunits);

reduction of intermediate levels of provision, concentration of major efforts in the air command and military units (subunits), where the expenditures of logistics are incurred;

optimization of processes of making logistic decisions based on efficiency indicators used in the logistics of the AF of the UAF;

automation of the processes of material, transport, evacuation, information and financial flows management [17];

the dependence of the efficiency of the solution of the increasing scope of tasks of logistics of the AF of the UAF on the amount of information used.

Trends in practice are realized through the principles of logistic support, which are consistent with legislative acts on national security and defense of Ukraine, the standards of logistics of NATO, and determine the specifics of the functioning of military units (subunits) of the UAF in the course of the preparation and conduct of operations (combat actions).

In essence, the principles of logistic support represent a provision according to which the necessary properties of the logistic system of the AF of the UAF are formed. At the same time, the principles of logistic support provide the basis for the construction and operation of the logistics system of the AF of the UAF.

Using these principles in practice it is possible to justify the recommendations for carrying out a complex of measures to determine the tasks of logistics, the order of management of the logistic system, the volume of weapons and military equipment, logistics and the order of their transportation and supply, the sequence, timing, methods of action, interaction, the necessary composition of the group of forces and logistics, the development of appropriate planning documents on troop-contributing tasks in peace and war time.

Thus, in accordance with the General Provisions of the Logistic Doctrine of the UAF [1], the principles of logistic support are the following: Priority, Sufficiency, Efficiency, Flexibility, Transparency, Coordination, Responsibility, Cooperation, Interoperability and Stability.

Together with the established laws, tendencies and principles of logistic support the AF of the UAF require to define the concept of forms and methods. In essence, forms of logistic support represent the actions of the logistics management authorities regarding the use of logistic assets. In the meantime the forms of logistic support are directly related to the forms of action of the military units (subunits) of the UAF and are important in the operation of the logistic system of the UAF. Therefore, the main forms of logistic support of military units (subunits) of the UAF are:

Logistic support for combat training and combat duty;

Logistic support for everyday activities;

Logistical support for mobilization, operational deployment and bringing into combat readiness;

Logistic support for operational and tactical regrouping;

Logistic support for the preparation and conduct of operations (combat actions);

Logistic support for the restoration of combat capability of military units (subunits).

In turn, logistical support for the preparation and conduct of operations (combat actions) it is expedient to identify:

Logistic support for military units (subunits) of the UAF in defence operations;

Logistic support for the preparation of military units (subunits) of the UAF for an counter offensive (offensive) operation during a defence operation;

Logistic support for military units (subunits) of the UAF in the counter-offensive (offensive) operation;

Logistic support for military units (subunits) of the UAF in the air operations of the UAF;

Logistic support of aircraft maneuvers of the AF of the UAF of Ukraine;

Logistic support for the regrouping of military units (subunits) of the UAF.

As UAV is the compound technical object at the management of UAV logistic it needs to use the method of planning of exit of compound technical objects (CTO) into repair during operation according to state. Practical use of this method needs execution of following actions [20]:

- Compound technical objects operation according to state with the accumulation data about CTO failures.
- Quarterly estimation of mean-time-to-failure of each compound technical object.
- Execution of the limit state check of compound technical objects.
- Verification of limit state achievement of the compound technical object.
- Prediction of the mean-time-to-failure for the next year.
- Verification of mean-time-to-failure achievement of limit value.
- Determination of quarter when the mean-time-to-failure achieves to the limit value.
- Planning of exit of CTO into repair for the next year in the quarter which is previous to quarter when the mean-time-to-failure achieves to the limit value.
- Execution of repair of compound technical object according to state.

The method of planning of exit of CTO into repair during operation according to state is explained by fig. 1.

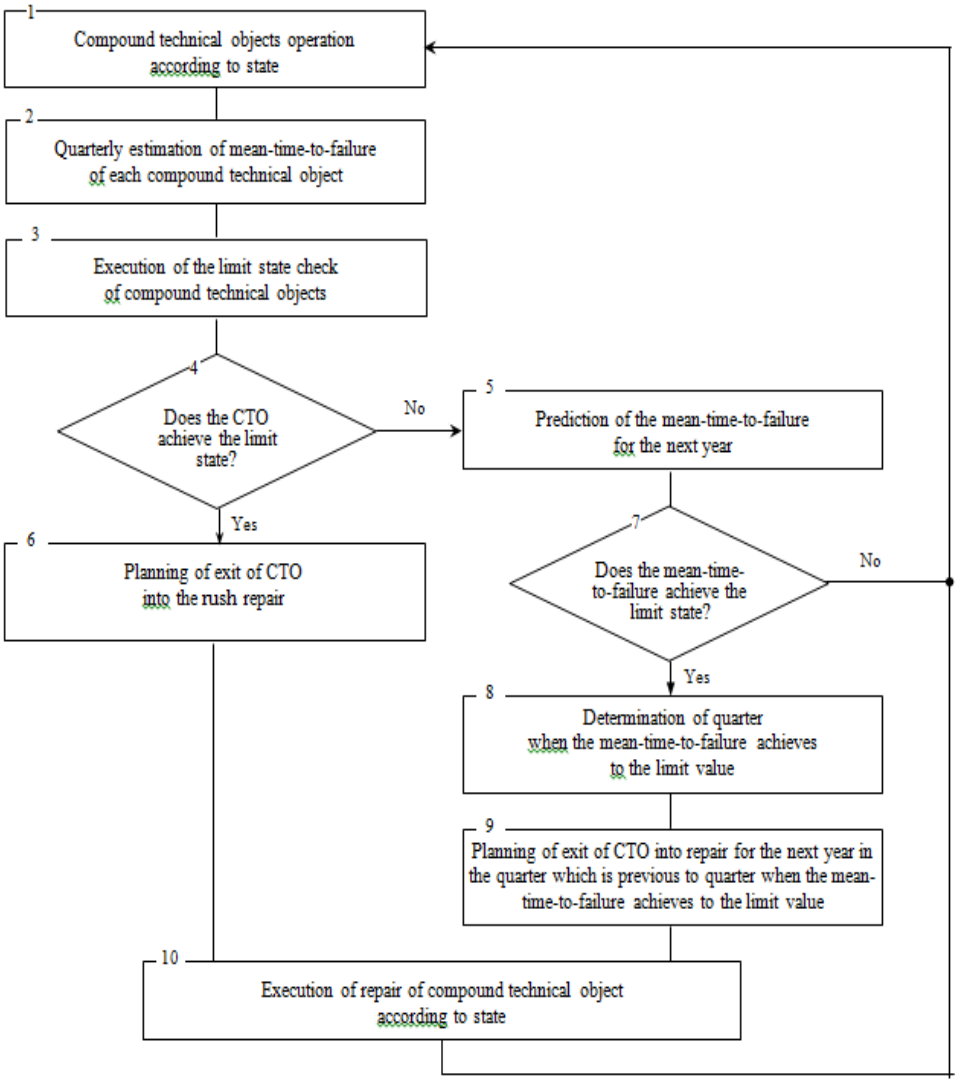

Fig. 1. Flow chart of the method of planning of exit of CTO into repair during operation according to state.

The results of limit state check (LSC) of compound technical s and the results of their operation between these checks are the initial data for application of method of planning of exit of CTO into repair during operation according to state. If during the LSC the limit state of compound technical object is fixed the object will need immediate repair according to state. For other CTO according to the result of operation the quarterly estimation of mean-time-to-failure is made.

Prediction of the mean-time-to-failure of each CTO for the next year is made on the quarterly estimations mean-time-to-failure and the results of LSC.

This planning method of compound technical objects exit into repair during operation according to state can be uses not only to UAV but to any radio electronic means (compound technical objects) which is the part of the missile guidance system [20, 21].

The implementation of these forms is carried out by means of logistic support. On the basis of the analysis of logistics systems in the leading countries of the world and NATO member-states, it is possible to define the content the "methods of logistic support" concept. This concept implies the complex of questions of theory and practice that characterize the order and methods of using assets of logistic support for the tasks of preparation and conduct of operations (combat actions). In this case, the logistics support methods will depend on:

the nature and methods of conducting operations (combat actions) of military units (subunits) of the UAF;

directions of concentration of the main efforts of logistics;

the available assets of logistic support and the sequence of their application;

the degree of centralization of the management of the logistics system and decentralization of the tasks of logistic support;

physical and geographical conditions of the area of operation and the nature of the deployment of assets of logistic support on the ground;

the nature of the maneuver and the regrouping of forces and means of logistic support.

Combinations of these factors determine a number of specific methods of logistic support that characterize the proposed forms of logistic support for military units (subunits) of the UAF in the course of conduct of

operations (combat actions). The choice of specific methods of logistic support for the AF of the UAF will be determined by the Deputy Chief of the logistics unit - Chief of the logistics of the AF in the process of making a decision on the organization of logistic support in the preparation and conduct of operation (combat actions). Changes in conditions during the conduct of operations (combat actions) will change the combination of factors, as well as the change in the methods of logistics in general. In the subsystems of logistic support of the AF of the UAF, at operational and tactical levels, each form of logistic support will correspond only to the inherent methods of these forms.

Conclusions and perspectives of further research

Thus, the functioning of the logistics system of the AF of the UAF taking into consideration the stated views on the logistics theory of the AF of the UAF should be assessed, based on the requirements for logistic support by assessing the totality of real capabilities of each subsystem that is part of it and the system as a whole. Also, more attention will be provided to the knowledge and skills required to perform UAV maintenance, the facilities required, and human factors training requirements.

In this case, the assessment of the quality of logistic support for military units (subunits) of the UAF can be related to the degree of implementation of the potential capabilities of the logistic system in solving the tasks of each subsystem during the stages of combat training, mobilization and operational deployment, preparation and conduct of operations (combat actions), restoration of combat capability of troops (forces).

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