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Main requirements for the operational and tactical calculations software complex based on the combat operations experience during the russian-Ukrainian war

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Abstract. The relevance of the researh is driven by the need to enhance the efficiency and quality of decision-making at all levels of military command in the context of repelling armed aggression. This necessitates the development of effective software complex for operational-tactical calculations that take into account modern combat realities [1].

In this regard, the aim of the article is to determine the key requirements for a domestic software complex for operational-tactical calculations that meets the current needs of the Armed Forces of Ukraine and enables headquarters to independently conduct the necessary calculations within short timeframes and with limited resources. The definition of these requirements is based on an analysis of the experience of using similar software complexes in leading armies worldwide and the practice of conducting calculations during the planning and execution of combat operations under modern conditions. This approach allows for a comprehensive examination of both methodological and technological aspects of system development.

The main requirements are conventionally divided into methodological and technological components. The necessity of incorporating modules for calculating the combat capabilities of troops [7, 8], determining the required forces and assets to achieve the operation's objectives, assessing the effectiveness of fires [9, 11], and modeling the probable course of combat operations [5] is substantiated. Additionally, the technological requirements for handling large data arrays, visualising results, and ensuring an adequate level of information security are outlined.

The materials of this article hold practical value for institutions and organizations responsible for the development and maintenance of military-purpose software systems, as well as for headquarters that utilize such systems in operational planning.

Keywords: operational and tactical calculations, software system, decision-making, combat planning, operations, combined fire support, automation, simulation modelling, performance evaluation, large-scale armed aggression.

Introduction

The experience gained during the repulsion of russia's large-scale armed aggression against Ukraine, as well as the analysis of trends in the course of armed conflicts of our time, shows that the success of operations (combat actions) largely depends on the efficiency and quality of decision-making at all levels of military command [1, 3, 6, 14]. Conducting operational and tactical calculations (OTC) is a long and labour-intensive process and, in the face of rapid changes in the situation, can lead to errors related to the human factor.

In general, OTC should be understood as the process of obtaining quantitative and qualitative indicators that characterise the capabilities of one's own and enemy forces in certain conditions. The

main purpose of the OTC is to increase the validity of commanders' decisions and eliminate the influence of subjective factors. At the same time, although the results of OTC are important auxiliary information for making appropriate decisions, they do not exclude the role of experience, intuition, and responsibility of commanders.

It is clear that OTCs are based on an appropriate methodological framework, and many methods have not proven their effectiveness in modern conditions, as they were based on significantly different assumptions and conditions. For example, the massive use of reconnaissance UAVs has virtually eliminated the concept of using missle forces and artillery against unobserved targets [10, 15]. This, in turn, will require a revision of a number of related methodologies, in particular those related to the calculation of the need for missiles and ammunition for the missle forces and artillery, as well as the need for strike UAVs and ammunition for them [2, 10]. The above example is not an isolated one; an analysis of the existing methodological basis for the OTC indicates that the problem extends to the area of assessing the effectiveness of the use of troops, i.e. it is complex.

Thus, the main requirements for the OTC software system can be divided into two main parts: requirements for the composition (in the methodological sense) of the software system and requirements for its technological capabilities.

The experience of using such software (modelling) complexes (systems) in the world's leading armies shows that their scope of application extends to almost all key aspects of the life of the armed forces [16-19]. As a rule, they are focused on a narrow specialisation of calculations, are based on the assumption of relative homogeneity of troop (force) groups, do not take into account time constraints for preparation and direct conduct of calculations and, most importantly, they do not fully take into account the experience of using modern weapons (unmanned systems, electronic warfare, intelligence systems, etc.). Moreover, foreign software systems are developed and maintained by third-party organisations on an outsourced basis, and support and decision-making systems are based on the results of previous calculations.

This analysis only underlines the urgency of completing the development of a national software system for OTC, which would allow the military command and control authorities to independently carry out basic operational and tactical calculations in a short time (in combat) and with limited forces.

Methodological Framework

The employment of software systems makes it possible to: to increase the level of awareness and cohesion of command and control authorities; optimise the number of troops (forces) involved in combat missions; simulate a complex situation; analyse and evaluate the actions of the parties under different options in the shortest possible time; promptly take into account changes in the situation; conduct a comparative analysis of decision options; create expert systems for their further use; and conduct simulations of combat operations, in particular to determine rational ways of employing troops. The experience of conducting operations (combat actions) since February 2022 makes it necessary to complete the development of OTC software systems. It is also advisable to study the experience gained by the armies of Ukraine's partner countries in this area. For example, a number of official documents of the US Department of Defence propose the following division (category) of methods with the allocation of seven functional areas of calculations (modelling):

- assessment of the effectiveness of formations in independent, joint and combined operations of types and branches of forces;
- military and scientific research and development of concepts in the field of construction of the armed forces and their combat use;
- combat support or support of operations (intelligence, electronic warfare, etc.);
- creation of weapons and military equipment (reduction of the cost of new models and

reduction of the time of their creation, including the sphere of research and development, design and procurement)

- testing and evaluation (of the needs of the armed forces, improvement of the quality of decision-making in the field of planning and development of budget programmes, evaluation of the effectiveness of new models of weapons and military equipment);
- logistics;
- operational and combat training, personnel training.

It should be noted that there is no specific distinction between these areas. For example, models intended for analysis and evaluation, in turn, are divided into two subgroups - research models (used in research), which provide new information, and models that support the operational work of headquarters, where simulation is associated with repeated playback of certain situations to acquire certain skills, in particular, in assessing the situation, making decisions and managing troops (forces).

In general, the world experience in the development and use of software (modelling) systems for military purposes is quite extensive. Among the most well-known foreign software (modelling) complexes (systems) are the following:

JTLS (Joint Theater Level Simulation) is an operational-level warfare simulation used by NATO for planning operations, training commanders and staffs. It allows simulating joint operations of multilateral forces (including air, land, maritime, logistics and special operations components) in real time. The inputs to JTLS are operational scenarios, force characteristics (numbers, weapons, logistics), terrain, and operational plans, which are entered through customisable databases. The results include an assessment of the course of operations, resource consumption, casualties and the effectiveness of decisions made, presented in the form of graphical reports and tables. The mathematical framework is based on the Lanchester equations for assessing conflicts between aggregate units (battalions, brigades), as well as stochastic models for modelling air and naval operations, which provides deterministic and probabilistic analysis [16, 19].

JCATS (Joint Conflict and Tactical Simulation) is positioned as a tactical-level combat simulation system designed to reproduce in detail the actions of individual units, soldiers and weapons in real combat scenarios. It is widely used for training and exercises, analysis of tactical decisions and evaluation of weapons effectiveness. The input data includes detailed characteristics of the equipment (speed, range, armour), terrain parameters (terrain, vegetation), weather conditions and operator behaviour, which are entered manually or imported from databases. The system produces results in the form of reports on losses, trajectories, target hits, and tactical consequences, which are displayed on a graphical interface. The mathematical basis of JCATS is based on probabilistic models (individual hit probabilities), consideration of physical laws (ballistics, motion) and a discrete-event approach that ensures high accuracy at the level of individual objects [17, 19].

CORSAGE (Corps and Division Simulation System) is a battlefield simulation system that focuses on analysing operations at the corps and division level, used to train commanders and evaluate operational plans. It focuses on the interaction of large military formations in complex scenarios. Inputs include unit structure (numbers, weapons, logistics), terrain maps, battle scenarios, and user commands entered through a specialised interface. The results include projected casualties, troop advances, resource expenditures, and assessment of the success of operations, presented in the form of reports and map data. CORSAGE's mathematical framework is based on a combination of deterministic models (e.g., for logistics and manoeuvres) and stochastic approaches to account for battle uncertainties, adapted to French military doctrine [19].

The JICM (Joint Integrated Contingency Model) is used as a system for assessing and analysing options for the use of troops in crisis situations, designed for strategic planning and analysis of ‘what-if’ scenarios. It is used to predict the outcome of conflicts and crisis operations based on integrated data. Inputs include force size and location, combat capabilities, logistical

parameters, geopolitical conditions, and alternative action plans, which are entered through analytical templates. The outputs are comparative scenario analyses, estimates of casualties, duration of operations, and probability of success, presented in tables and graphs. JICM's mathematical framework combines statistical models, game theory and aggregate approaches to combat assessment, enabling rapid analysis of complex crisis situations with a focus on strategic implications. These systems provide comprehensive modelling of combat operations, taking into account the interaction of different types and branches of the armed forces, the impact of terrain, weather conditions, and the capabilities of intelligence and control systems. They allow to evaluate the effectiveness of various options for the use of troops and choose the best solutions [16].

The key disadvantage of such software (modelling) complexes (systems) is the time required to enter and edit the necessary data [6, 14]. The output data does not contain complex coded information, but its creation 'from scratch' is quite labour-intensive and can take from a week to several months.

Although the above-mentioned software systems have relatively good capabilities for calculating the capabilities of troops (in particular, in terms of visualisation of the results), the time required to prepare the necessary input data, especially in combat conditions, is unacceptable. This determines one of the main technological requirements for OTC software systems - the efficiency of obtaining results. The above determines the need to optimise the work with significant data sets, while with the growth of the scale of the actions in relation to which the OTC is conducted, the relevance of optimising the time indicators for preparing input data only increases - the data sets on the combat and numerical composition of the opposing groups, the volume and list of required characteristics of weapons and military equipment, etc.

Regarding the composition of the methodological base of the OTC software complex, it should be noted that the practice of conducting calculations during the planning and conduct of combat operations has confirmed the need to obtain an assessment of the combat (primarily fire and strike) capabilities of troops, determine the need for assets for an operation (combat operations), and assess the effectiveness of fire damage to the enemy. It should also be noted that the complex should include a mathematical model of operations that would allow to evaluate different variants of ways of conducting combat operations [4, 11, 12, 13, 15].

Assessment of combat capabilities forces groupings is based on a set of methods that allow to characterise the fire, striking and manoeuvring capabilities of troops. Some of the previously developed methods remain relevant in modern conditions. For example, the quantitative and qualitative ratio of the parties' groups of troops can be determined using the combat capabilities of the groups, and this ratio can be extended to individual types of weapons (an example of assessing this ratio is shown in Figure 1).

In addition, one of the most important indicators of the striking power of troops of groups is the maximum depth of advance into the enemy's location; this indicator, along with the assessment of losses of their own and enemy troops, makes it possible to assess the potential capabilities of troops of groups in the most general way.

An illustrative example of the results of determining the above indicators is shown in Figure 2.

It is obvious that the list of combat capabilities indicators of troops groups is much wider, however, the limited scope of the article does not allow us to consider each of them in detail. It is considered necessary to focus only on the key aspects of the methodological part of the software complex, so in accordance with the proposed conditional division of the main requirements for the methodological component of the OTC software complex, the presence of modules that allow calculating indicators of combat capabilities of troops, modeling the likely course and results of hostilities (assessing options for the employment of troops) should be considered as part of the complex [19].

Offensive operation

Own formations: 901 BDE 1000 A, 902 BDE 1000 A, 903 BDE 1000 A
Enemy formations: 701 BDE 1000 A, 702 BDE 1000 A, 703 BDE 1000 A

Force Ratio

	Friendly Forces			Force Ratio		Enemy		
	Unit	Density	CP	Unit	CP	Unit	Density	CP
Tank	144	28.80	288.72	1:1.47	1:1.88	212	42.40	543.63
ACV	386	77.20	327.68	1:1.21	1.09:1	467	93.40	299.85
Artillery Systems	392	78.40	429.55	2.78:1	2.49:1	141	28.20	172.35
Anti-tank weapons	137	27.40	164.56	1:1.87	1:2.00	256	51.20	328.56
MLRS	9	1.80	24.48	1:11.22	1:4.95	101	20.20	121.20
Grenade launcher	143	28.60	31.70	1:2.22	1:1.00	318	63.60	31.80
Unmanned combat aerial vehicle	77	15.40	64.68	1:1	1:1.16	77	15.40	74.84
Personnel and other	410	82.00	82.00	1:1.48	1:1.48	606	121.20	121.20
Personnel	12187	2438		1:1.12		13602	2721	
Total			1413.37		**1 : 1.20**			1693.43

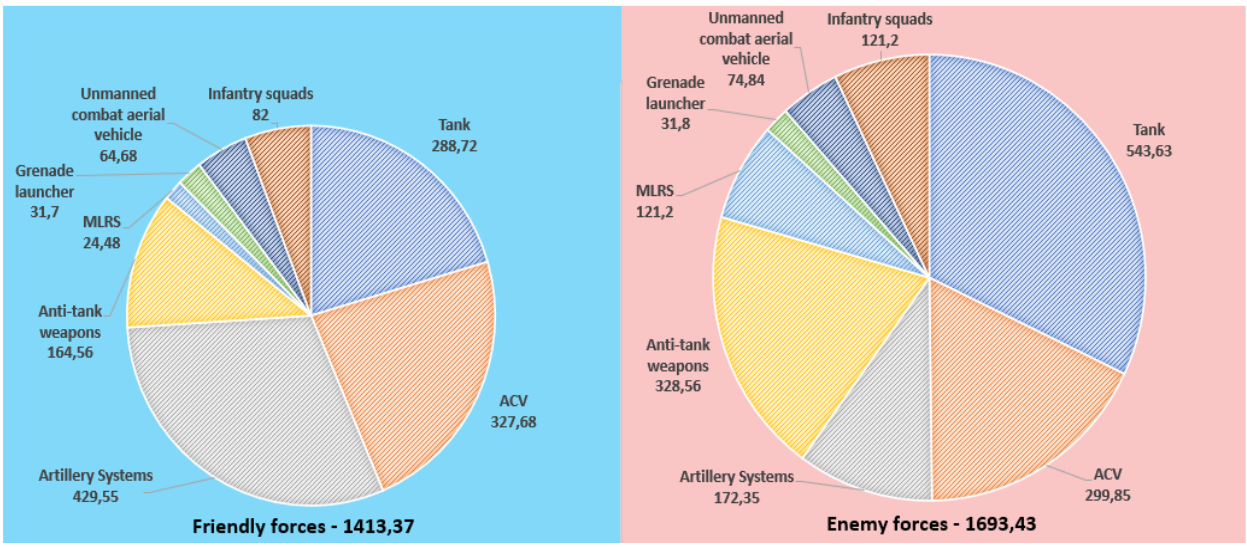


Figure 1. An example of a quantitative and qualitative assessment of troops groupings assets (option)

It is extremely important and necessary to fundamentally revise the provisions that determine the calculation of the need for aasets required to achieve the purpose of the operation, as well as the assessment of the firearms effectiveness [11].

The main technological requirements include the convenience of working with large amounts of data, entering, storing, correcting, updating, and ensuring their security, in particular when exchanging data. Another important requirement is the visibility of the results of operational and tactical calculations, in particular, using the modern capabilities of geographic information systems [12].

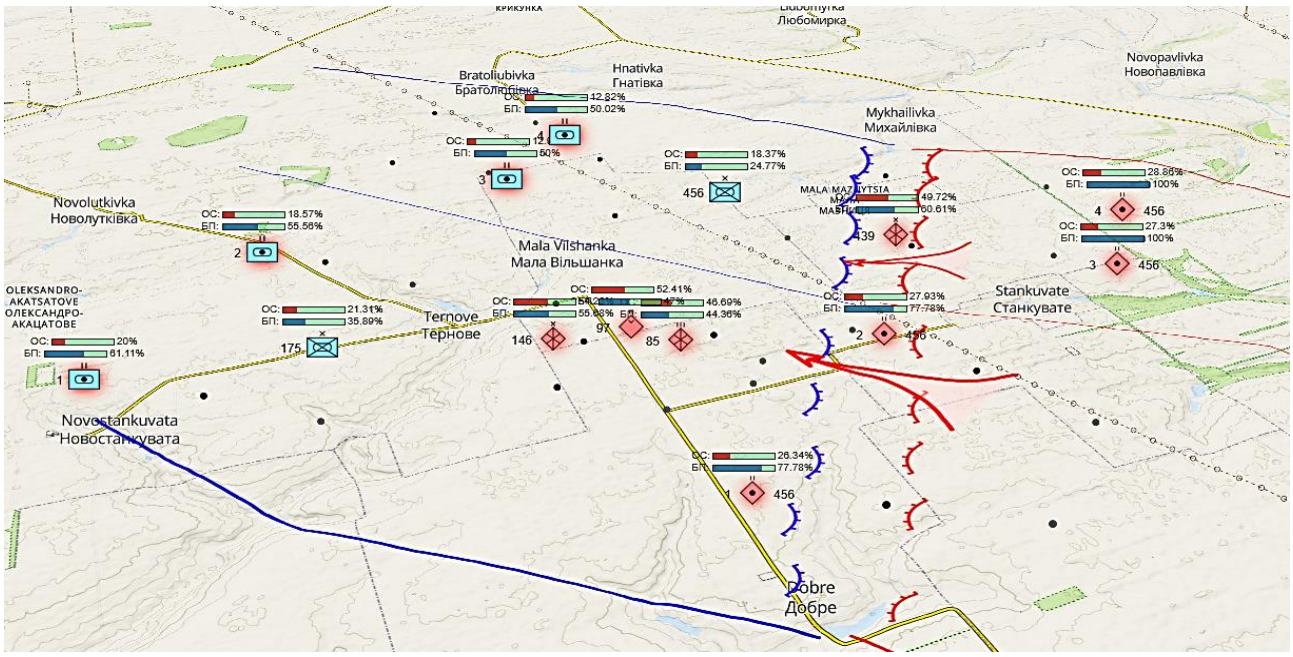


Figure 2. Visual representation of troops' partial combat capability indicators (option)

Results

An analysis of current trends in the development of software tools designed to conduct operational and tactical calculations in the world's leading armies, as well as the experience gained during large-scale armed aggression, has revealed the following. The OTC software package is a necessary auxiliary tool for military command and control authorities of operational and tactical and higher levels in planning operations (combat actions).

Improvement of OTC techniques and their programme implementation is an ongoing process that requires constant improvement based on the experience of combat operations. The realities of conducting OTC indicate that a number of methods, after appropriate refinement, have confirmed their efficiency and effectiveness, and the frequency of their use suggests the absolute need for implementation as part of a complex.

In particular, in terms of assessing the combat capabilities of troops, it is advisable to use indicators that characterise:

combat capabilities of military formations, taking into account their manning, level of training, moral and psychological state of personnel and provision of ammunition;

projected losses of weapons and military equipment, taking into account the ratio of parties assets, the intensity of hostilities, the involvement degree of armoured vehicles and the duration of the operation;

projected losses of personnel, taking into account the intensity of the ratio parties assets, the preparedness of personnel, the intensity of hostilities and the duration of the operation;

the advance depth of the advancing party, taking into account the nature of the terrain, the density of troops, the width of the breakthrough areas, the type of defence, the degree of permissible losses of the parties, etc.

The provisions of the previously developed Methodology for operational and tactical (tactical) calculations in planning the fire damage of the enemy by missile forces and artillery in a combat operation (in terms of determining the need for assets and assessing the effectiveness of the fire damage assets employment) will need to be significantly revised. It is also important to improve the mathematical model of operations (combat operations), which would allow to evaluate different

variants of warfare methods and take into account the experience of developing and using similar models in the armies of Ukraine's partner countries.

The main result of the article should be considered the main requirements for the software system of the OTC, formed as a result of the analysis of the current state of affairs in this area and the experience of repulsing the large-scale armed aggression of the russian federation against Ukraine.

Discussions

A significant number of publications, in particular [6-11], are devoted to the consideration of issues related to the topics raised in the article. The key problem with existing software products (complexes, systems), both in world practice and in domestic developments, is their functional inadequacy to the changes inherent in modern warfare with the use of new weapons and military equipment, in particular unmanned systems and complexes, which are now becoming increasingly important [15].

There are two ways of adapting OTC software systems to modern realities: improving existing software developments or creating fundamentally new ones. The authors do not aim to determine the appropriate way of such adaptation, as this is a separate issue that requires careful justification. But, in any case, the basic requirements for a software system are the starting point from which to make appropriate decisions. A similar opinion can be traced in several modern publications, in particular [5, 6, 14].

Conclusion

Based on the results of the current trends analysis in the conduct of armed fighting, as well as the world experience in the development and employment of software systems and military systems, the article formulates the main requirements for the OTC software complex. They are conditionally divided into requirements for the methodological component of the complex and the most general requirements for its technological capabilities and are as follows.

The software complex must be implemented:

methodologies that calculate the main combat capabilities indicators troops groups (in particular, combat capabilities of military formations, projected losses of personnel, weapons and military equipment of their own and enemy troops, depth of advance, capabilities of anti-tank weapons, attack UAVs, small arms, etc;)

methods that determine the need for assets to achieve the purpose of the operation and assess the effectiveness of the firearms employment;

a mathematical model of operations (combat actions) that would allow determining the appropriate ways to employ troops.

In terms of technology, the OTC software system should ensure stable and convenient work with large amounts of data (input, storage, correction, updating, security), as well as display the results of operational and tactical calculations on electronic maps of the area. In addition, the software system must ensure the required level of data security (both input and calculation results).

Recommendations

The materials of the article may be useful for institutions and organisations tasked with the development and maintenance of software systems and systems for military purposes.

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