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O. Semchak

V. Didyk

S. Pavlenko

DEVELOPMENT OF AN INFORMATION-ANALYTICAL SUBSYSTEM FOR AN AUTOMATED TACTICAL LEVEL CONTROL SYSTEM

An analysis of methods used by management bodies has been conducted, indicating the necessity of finding the most acceptable methodological apparatus for substantiating decisions regarding the application of units and subunits to counter armed and other provocations by the enemy in the area of combat missions performance.

The issue of the inconsistency between the necessity of countering threats posed by the enemy's troops in the defense area of a battalion (combat order during the offensive) and the absence of a methodological apparatus that would allow to form a rational distribution of units and subunits under these conditions for conducting combat operations has been raised.

Methods and algorithm have been proposed that enable the determination of the degree of correspondence between external informational indicators of data received at the battalion command post and typical informational indicators of necessary information for use during the decision-making process for the application of units and subunits, allowing timely measures to be taken to prevent negative consequences for the national security of the state during the combat operations conducted by units and subunits of the Armed Forces of Ukraine.

Keywords: *information-analytical subsystem, information indicators, automated control system, information.*

Statement of the problem. Today, an important task is to increase the probability of the reliability of information for conducting specific measures within the allotted time. To implement this, tools are needed that will allow determining the degree of correspondence between external information indicators for the work of the battalion commander and headquarters to typical information indicators regarding the necessary measures for the successful planning and organization of combat operations by their units.

Based on the results of the conducted research, an applied scientific task is formulated. In this case, it comes down to developing methods for synthesizing the structure of the automated tactical level control system for the Armed Forces of Ukraine as a result of the informational analytical subsystem implementation. That will improve the process of managing units and subunits according to NATO standards.

Solving the stated problems is possible through improving the structure of the informational analytical subsystem for the automated tactical level control system, which will allow a rational distribution of subunits to gain an advantage over the enemy.

Analysis of recent research and publications. The issue of information quality has been explored in a number of scientific works, some of which are presented in the list of sources [1, 3, 8, 9, 10]. However, during the practical assessment of information used in the course of information provision, theoretical provisions are usually reduced to entropy assessment methods, which require the presence of the probability of events and states, and to well-known general recommendations, which cannot be implemented in the information provision system, since the set statistics for estimating the probability of events is questionable.

The purpose of the article is to increase the effectiveness of the automated tactical level control system by developing a methodological apparatus for calculating the parameters of the informational analytical subsystem structure for the automated tactical level control system.

Summary of the main material. To increase the probability of carrying out the specified measures within the allotted time, methods and algorithm are needed that will make it possible to determine the correspondence degree between external information indicators for the work of the battalion commander and headquarters and typical information indicators regarding the necessary measures for the successful implementation of combat operations planning and organization for their units [12].

In a battalion, the process of combat planning (actions) begins after receiving a combat mission in the form of a combat order (OPORD) or preliminary combat order (WARNO) and consists of seven stages.

1. Receiving a combat mission. Development and issuance of preliminar combat order (WARNO) [combat preparation instructions (actions)].

2. Analysis of the combat mission and situation assessment. Determination of the preliminary plan for the battle (action).

3. Development of actions options (COAs *Development*).

4. Analysis of actions options (COAs *Analysis*) and conducting battle (actions) modeling (war games).

5. Comparison of actions options (COAs *Comparison*).

6. Approval of the action option (COA *Approval*). Formulation of the plan, approval of the plan by the senior commander.

7. Reconnaissance (if possible). Decision formulation. Development and issuance of the combat order (*Orders Production*) and execution of a set of organizational work.

As a result of the analysis of the scientific-methodical apparatus under consideration, it was established that the existing methods do not fully take into account the cause-and-effect relationships between the ways of implementing aggressive threats in the areas of combat operations and the parametric data of the enemy's reconnaissance and sabotage groups. The analysis of methods used by command and control bodies indicates the necessity of finding the most acceptable methodological apparatus for substantiating decisions regarding the application of units and subunits to counter armed and other provocations by the enemy in the area of performing combat missions [1, 9, 12].

The identified questionable issues indicate the existence of_inconsistencies in theory and practice between the necessity of countering threats posed by the enemy's troops in the defense area of the battalion (combat order during the offensive) and the absence of a methodological apparatus that would allow the formation of a rational distribution of units and subunits under these conditions.

Taking into account the mentioned shortcomings, the procedure for forming the methods for determining the parameters for the structure of an informational analytical subsystem for an automated control system and the interconnection of expected scientific results has been developed, which is presented in Figure 1.

At the initial stage of the research, it is necessary to analyze the tasks assigned to tactical level control units and subunits, as well as to study the current state of application and analysis of approaches to the construction of automated control system (ACS) for units and subunits. According to the obtained data and additional information about modern means of automating the control of units based on modern technologies, it is necessary to analyze approaches to developing models of automated systems for tactical command level (AS TCL), as well as synthesis of informational analytical systems. In this case, it comes down to developing a methodology for synthesizing the structure of an automated tactical level control system as a result of implementing the information-analytical subsystem (IAS).

After completing the mentioned stages of the structural logical scheme of the research, the necessary information for justifying recommendations and technical requirements for forming the informational analytical subsystem for the automated control system, as well as other specified scientific results, will be obtained.

To ensure the adequacy of the proposed methodology, it is necessary to develop indicators of information quality used in the management of units and subdivisions of the Armed Forces of Ukraine (AFU) [8].

Information needed by the command staff of units and subdivisions for management at each level (command, brigade commanders and headquarters, battalion commanders and headquarters, company and platoon commanders) may vary depending on the levels of management: strategic, operational, and tactical.

Regarding the real process (object or tactical situation), from the standpoint of the tasks and goals of actions of units and subunits, information can belong to the categories of "factual" – true, "factual-predictive" – factually planned actions of the enemy based on intelligence data, and "predictive" – possible.

The criterion of sufficient reliability, completeness and consistency of information can be the provision of the maximum probability of completing the tasks assigned to units and subunits with the available forces promptly applied. Inaccurate ("fuzzy") data leads to the need to count on worse conditions for the performance of tasks and, accordingly, demand large necessary resources (forces and means) and other types of troops of the Armed Forces of Ukraine. The lack of resources or the values of information quality indicators may determine the need for actions to timely obtain [and (or) forming] additional information.

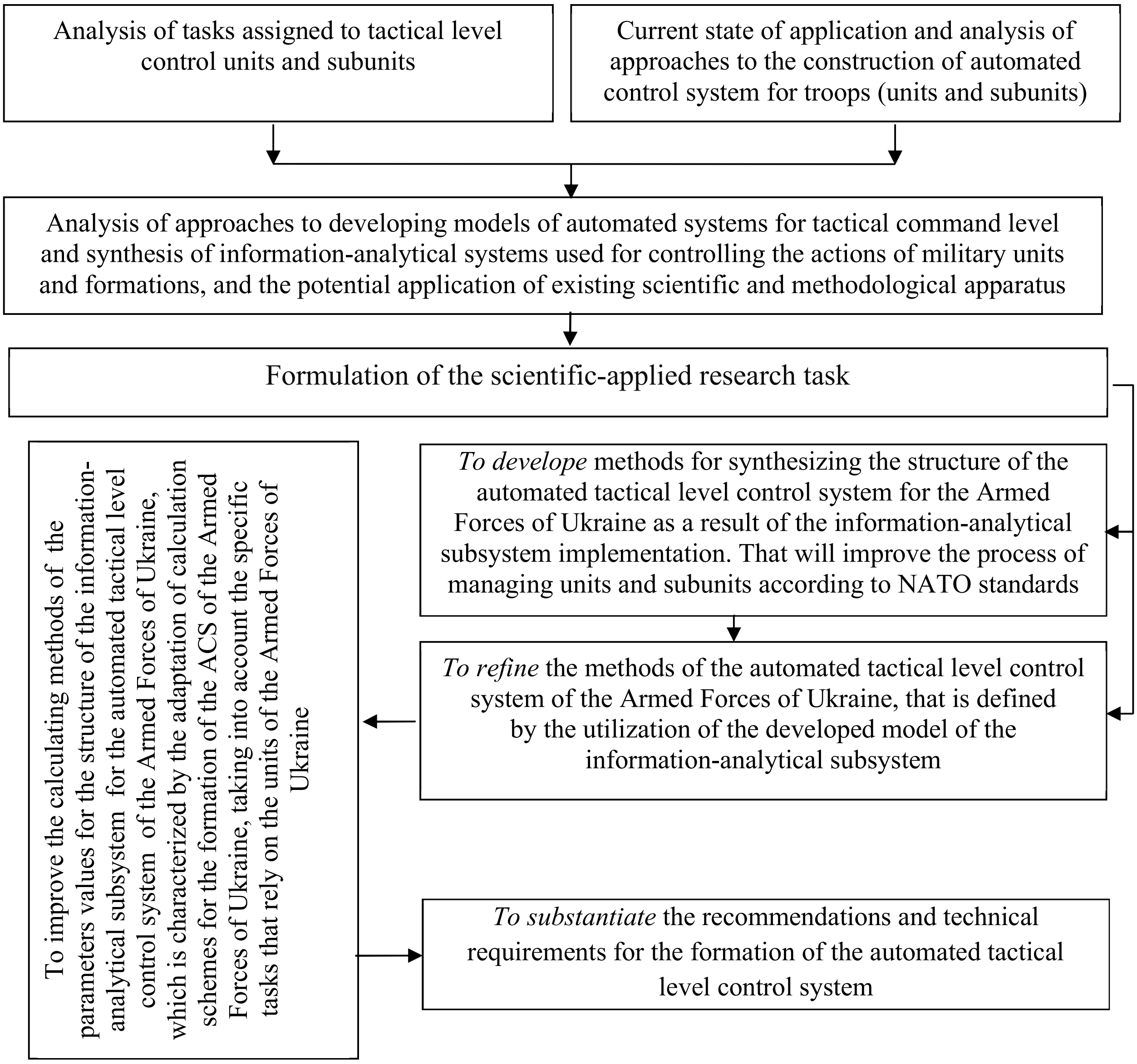

Figure 1 – Structural-logical scheme of the research

The criterion of sufficient reliability, completeness and consistency of information can be the provision of the maximum probability of completing the tasks assigned to units and subunits with the available forces promptly applied. Inaccurate ("fuzzy") data leads to the need to count on worse conditions for the performance of tasks and, accordingly, demand large necessary resources (forces and means) and other types of troops of the Armed Forces of Ukraine. The lack of resources or the values of information quality indicators may determine the need for actions to timely obtain [and (or) forming] additional information.

While managing the actions of units and subunits, the widest possible range of forecasts is usually used at all levels of command and control, taking into account the necessary prediction time, which varies for different levels of command and control. In terms of nature, content, and time of a management cycle forecasts can be [6, 7]: current, operational, medium-term, long-term, and prospective.

At the same time, in the conditions of dynamic events during combat operations, the previously obtained information about the situation can be changed during a decision-making process. This necessitates constant refinement of the basic data which is used by officers for information monitoring and which is subject to aging.

Aging of information leads to a decrease in its reliability – the degree of correspondence to reality. The main reason for the aging of information is the development of a real process [1, 6, 12]. At each level of management, the ratio of the time available for a task execution to the required time for decision-making and execution is critical for task accomplishment.

According to article [1], the fact of information aging determines the need to use the initial reliability indicator R0 of information at the time of its receipt from the source and the calculation chart for evaluating reliability taking into account the time elapsed since the information was received. Average statistical estimates of the time for decreasing the reliability of information by levels of management and types of decision-making are given in Table 1.

To find the approximation formula for the dependence of an information reliability indicator on time at the i-th level of management of the j-th decision term, we will use the origin point, where the reliability indicator is maximum ($R = R_0 = R_{max}$), and the point (t_1) with a reliability level $R(t_1) = R_1 = 0{,}5$. The approximation formula, for which the curved line will surely pass through these two points, will look like this:

$$R_{ij} = R_o e^{-b_{ij} t_{ij}}; \ |R_o = 1|; \ \rightarrow \ R_1 = e^{-b_{ij} \times t_{ij.1}}; \ \rightarrow \ b_{ij} = \frac{ln\, R_1}{-t_{ij1}} = \frac{ln \ \ ,5}{-t_{ij1}} = \frac{-0{,}6931}{-t_{ij}}. \quad (1)$$

In the considered case, the approximation coefficient will have the value as presented in Table 2, where i is the level of management number (row of the table), and j is the decision urgency type number (column of the table). The decrease in information reliability at the tactical level during the making both current (R_{11}) and operational (R_{12}) decisions for the conditions $R_0 = R_{max} = 1$ is shown in Figure 2.

It is worth noting that the sources of information providing data for decision-making have the primary value of the evaluation indicator $R_0 = 1$. Further, according to expression (1), this value changes, requiring the use of additional sources of information or the specification of data from the source that provided the information, which has changed its reliability over time. Based on the analysis of data [5–10], a list of the main informational characteristics can be identified, the change of which over time, as available, leads to a significant decrease in information reliability (see Table 3).

Table 1 – Evaluation of the time t_1 for the reduction of an information reliability indicator used for decision-making to the level of 0,5

Type of decision (j), unit of time	Level of management (i)		
	TL	OL	SL
Current, hour	1,0	2,0	3,0
Operational, hour	2,0	3,0	3,5
Medium-term, day	15,0	25,0	30,0
Long-term, month	2,0	4,0	6,0
Prospective, year	1,5	2,5	3,0

Table 2 – Values of approximation coefficients b_{ij} in formula (1) according to Table 1

Level of management (i)	Current, hour	Operational, hour	Medium-term, day	Long-term, month	Perspective, year
Tactical	0,6931	0,3466	0,0462	0,3466	0,4621
Operational	0,3466	0,2310	0,0277	0,1733	0,2773
Strategic	0,2310	0,1980	0,0231	0,1155	0,2310

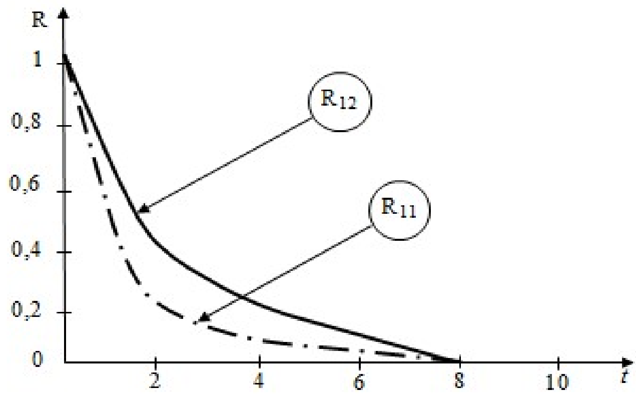

Figure 2 – Graph of Information Reliability Decrease at the Tactical Level when Making, respectively, Current (R_{11}) and Operational (R_{12}) Decisions, Provided $R_0 = R_{max} = 1$ [refer to formula (1) and Table 2]

Table 3 – List of the main informational characteristics, the change of which can lead to a significant decrease in information reliability

No.	Information indicators leading to decreased reliability of information
1	The emergence near our positions, the location of units of individuals (civilians) who are observing our units and subunits with possible photo and video recording
2	An attempt to obtain data about the units location's security and defense system, in particular through our military personnel
3	Capture and/or destruction of buildings, railway stations, ports, cultural or religious buildings
4	Armed attacks on settlements, shelling of residential buildings, schools, hospitals, administrative buildings, and locations of military personnel or law enforcement officers and other military formations
5	Radioactive, chemical, biological (bacteriological), and other contaminations of the area
6	Unusual activity behind enemy lines (both during the day and at night) according to intelligence, aerial photographs, and unmanned aerial vehicles
7	Movement along roads and railways, activity at stations, and accumulation of enemy vehicles
8	The enemy's artillery occupies its positions, the aviation activity intensifies, preparations for advancing columns: passages appear in wire, mine barriers, etc
9	Enemy artillery preparation
10	Other factors and parameters

The duration of the decision-making and execution process is associated with difficult-to-predict events (errors in initial data, calculations, occurrence of unforeseen circumstances, etc.) and is a random variable, which necessitates assessing the probability of timely decision-making and execution. This probability characterizes the promptness of decision-making and execution and can be measured by an indicator of timeliness [1]:

$$P_i = 1 - \exp\left(-\frac{t_н}{t_{n_i}}\right), \qquad (2)$$

where $t_н$ – time available for reacting to an event;

t_{ni} – time required for decision-making and execution at the i-th level of management.

If the timeliness indicator is insufficient ($P_i \le P_{i.гр}$), it is necessary to increase the speed of information acquisition and processing, which may require making decisions at a lower level of management where this information first appears, thereby reducing the information transmission delay.

To assess the degree of consistency between the initial and required sets of indicators, component-wise comparison of the vectors of required and available information is crucial. This comparison can determine the necessity of decision-making regarding component selection. In this case, the indicator of information consistency can be the cosine of the angle between the vectors of required and available information:

$$\cos\theta = \frac{1}{ab}\sum_{i=1}^{n} a_i b_i = \gamma , \qquad (3)$$

where a and b are the lengths of the vectors of required and available information;

(a_1, a_2, …, a_n) and (b_1, b_2, …, b_n) are the coordinates of vectors a and b.

Under the condition of complete consistency, the angle between the vectors is zero ($\theta = 0$), and $\cos\theta = 1$. The criterion for the sufficiency of the information consistency level can be the fulfillment of the condition $\cos\theta \geq g_{тр}$ ($0 < g_{тр} \leq 1$).

However, the components of data within the information set may have varying importance concerning the objectives and goals, which necessitates the use of weighting coefficients α_i for the significance of the data.

The overall reliability of threat assessment and risk analysis in the information-analytical system depends on the quantity and importance of informational components (factors, indicators, and parameters) considered in the system, the reliability of the sources and the information itself. It can be evaluated for the k-th management level by a special reliability indicator D_k ($D_k \leq 1$), while the degree of completeness of the system's work results can be assessed by the indicator Y (for an "ideal system") $t_{ni} \to 0$, $D_k = P_k = Y = 1$):

$$D_k = \sum_{i \in q_j} R_{ki} \alpha_{ki} \qquad Y = \sum_{k=1}^{Q} \xi_k D_k P_k$$
$$R_{ki} = R_0 P_{ki}\,, \tag{4}$$

where α_{ki} – weight of importance of the i-th parameter considered in the system for assessing threats and risk analysis at the k-th management level in relative units;

P_{ki} – decision-making speed indicator for the i-th parameter at the k-th management level for each sought decision parameter;

ξ_{ki} – weight importance indicator of the i-th decision parameter at the k-th management level;

Q – number of parameters and indicators required for decision-making.

The formed system of information quality indicators necessary for the current assessment of information needs in the management system enables both overall and component-wise (vector) comparison of the required information with the available data and allows decisions to be made regarding the selection of necessary components, as well as evaluating the achievable reliability of threat assessment and risk analysis.

Conclusion

The presented methodology allows determining the degree of compliance of external information indicators of the data received by the battalion control center with the typical information indicators of the necessary information for use in making decisions on the use of units and subunits, which allows timely measures to prevent negative consequences during combat operations.

Therefore, the goal of this research as for enhancing the effectiveness of the automated tactical level control system is achieved by developing methodological apparatus for calculating the parameters of the information-analytical subsystem structure for the automated tactical level control system.

Further research direction could involve developing methods for determining the significance of factors influencing the information-analytical subsystem of the automated tactical level control system of the Armed Forces of Ukraine.

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О. М. Семчак, В. О. Дідик, С. О. Павленко

РОЗВИТОК ІНФОРМАЦІЙНО-АНАЛІТИЧНОЇ ПІДСИСТЕМИ ДЛЯ АВТОМАТИЗОВАНОЇ СИСТЕМИ ТАКТИЧНОЇ ЛАНКИ УПРАВЛІННЯ

На сьогодні важливим завданням є підвищення імовірності достовірності інформації для проведення визначених заходів за відведений час. Для реалізації цього необхідні інструменти, які дадуть змогу визначити ступінь відповідності зовнішніх інформаційних ознак для роботи командира та штабу батальйону типовим інформаційним ознакам щодо необхідних заходів для вдалої реалізації планування й організації бойових дій своїх підрозділів.

За результатами проведених досліджень сформульовано науково-прикладне завдання дослідження. У цьому випадку воно зводиться до розроблення методики синтезу структури автоматизованої системи тактичної ланки управління Збройних Сил України шляхом упровадження інформаційно-аналітичної підсистеми, що дає можливість удосконалити процес управління частинами та підрозділами за стандартами НАТО.

Проведено аналіз методів, які використовуються органами управління, що свідчить про необхідність пошуку найприйнятнішого методичного апарату для обґрунтування рішень щодо застосування частин і підрозділів для протидії збройним та іншим провокаціям противника у районі виконання бойового завдання.

Порушено питання щодо наявності невідповідності у теорії і практиці між необхідністю протидії загрозам застосування противником своїх військ у районі оборони батальйону (бойового порядку під час наступу) та браком методичного апарату, який би давав змогу формувати раціональний розподіл частин і підрозділів у зазначених умовах для ведення бойових дій. Подано методику й алгоритм, що дають можливість визначити ступінь відповідності зовнішніх інформаційних ознак даних, які надходять на пункт управління батальйону, типовим інформаційним ознакам необхідної інформації для використання під час прийняття рішення на застосування частин і підрозділів, що дозволяє своєчасно провести заходи щодо запобігання негативним наслідкам для національної безпеки держави під час ведення бойових дій частинами і підрозділами Збройних Сил України.

Ключові слова: *інформаційно-аналітична підсистема, інформаційні ознаки, автоматизована система управління, інформація.*

Semchak Oleksandr – Ph.D, Associate Professor at the Department of Management of Military Intelligence Units and Special Operations Forces of the Military Academy (Odessa)
https://orcid.org/0000-0002-4480-2393

Didyk Valentyn – Senior Researcher at the Research Department of Development and Application of Combat Gear Complexes for the Air Assault Forces, Military Intelligence of the Ground Forces, and the Marine Corps of the Armed Forces of Ukraine at the Scientific Center of the Military Academy (Odessa)
https://orcid.org/0000-0003-4267-9122

Pavlenko Serhii – Candidate of Military Sciences, Associate Professor, deputy head of the Department of Logistics of Units at the National Academy of the National Guard of Ukraine
https://orcid.org/0000-0001-5944-8107