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HR 70-14

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1606

CENTRAL INTELLIGENCE AGENCY
WASHINGTON, D.C. 20505

26 August 1976

MEMORANDUM FOR: The Director of Central Intelligence

FROM : William W. Wells
Deputy Director for Operations

SUBJECT : MILITARY THOUGHT (USSR): Methods for Calculating Reconnaissance Capabilities Using High-Speed Computers

1. The enclosed Intelligence Information Special Report is part of a series now in preparation based on the SECRET USSR Ministry of Defense publication Collection of Articles of the Journal "Military Thought". This article describes an analytical model of reconnaissance activity in which reconnaissance functions are formalized to incorporate limitations and assumptions, and constant and variable information, for use with high-speed computers to assess the effectiveness of the reconnaissance of enemy targets. The authors examine the procedure for using this model, which is presented graphically in a block diagram, in different variants in order to obtain the optimum arrangement of reconnaissance personnel and equipment of varying capabilities against targets of varying types and importance. The concepts of final reconnaissance and periodic observation of targets also are explained in this general context. This article appeared in Issue No. 1 (86) for 1969. [redacted]

2. Because the source of this report is extremely sensitive, this document should be handled on a strict need-to-know basis within recipient agencies. For ease of reference, reports from this publication have been assigned [redacted]

[redacted]
William W. Wells

[redacted]

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Intelligence Information Special Report

[redacted]

COUNTRY USSR

DATE OF INFO. Early 1969

DATE 26 August 1976

SUBJECT

MILITARY THOUGHT (USSR): Methods for Calculating Reconnaissance Capabilities Using High-Speed Computers

SOURCE Documentary

Summary:

The following report is a translation from Russian of an article which appeared in Issue No. 1 (86) for 1969 of the SECRET USSR Ministry of Defense publication Collection of Articles of the Journal "Military Thought". The authors of this article are Colonel V. Volobuyev and Lieutenant Colonel R. Trofimov. This article describes an analytical model of reconnaissance activity in which reconnaissance functions are formalized to incorporate limitations and assumptions, and constant and variable information, for use with high-speed computers to assess the effectiveness of the reconnaissance of enemy targets. The authors examine the procedure for using this model, which is presented graphically in a block diagram, in different variants in order to obtain the optimum arrangement of reconnaissance personnel and equipment of varying capabilities against targets of varying types and importance. The concepts of final reconnaissance and periodic observation of targets also are explained in this general context.

End of Summary

[redacted] Comment:

Colonel Volobuyev also wrote "Reconnaissance - Combat Functions for Reconnaissance" in Issue No. 2 (87) for 1969 [redacted] and "Reconnaissance Independence of a Tank Army" in Issue No. 2 (81) for 1967 [redacted]

Methods for Calculating Reconnaissance Capabilities Using High-Speed Computers

by
Colonel V. Volobuyev
and
Lieutenant Colonel R. Trofimov

The interests of ensuring and maintaining a constant and high degree of troop combat readiness prior to the beginning of combat actions and while they are in progress, as well as the nature of modern operations, urgently require that a scientifically-based method of assessing the effectiveness of reconnaissance be worked out and introduced into practice in the troops.

One of the possible ways of solving this problem is the use of <u>mathematical methods for calculating the capabilities of reconnaissance forces and means</u> by using high-speed computers.

The difficulty of this problem lies in the fact that ways must be found to translate reconnaissance activity into the language of numbers, that is to express quantitatively the laws governing this complex process as a whole, and the numerous parameters influencing the capabilities of reconnaissance forces and means in particular.

Every qualitative phenomenon can be expressed objectively through quantitative indices. In this case we must choose, substantiate scientifically, and determine the importance of selected criteria for assessing the effectiveness of reconnaissance forces and means, and to decide among them which are the primary and the secondary, the general and the particular.

Another difficulty lies in the fact that for general criteria one must find comparable coefficients which make it possible to assess different technical and conventional reconnaissance means and reconnaissance organs that vary in function, principles, methods, security of operation, maneuverability, and other characteristics, and also to assess the effectiveness of a whole system of various reconnaissance means.

Help in overcoming these difficulties will be provided, in our opinion, by the proposed methodology, which is based on a detailed operational-tactical description of the task, and which establishes the prerequisites for identifying the basic laws governing reconnaissance activity and facilitates constructing a model of this activity.

On the basis of an operational-tactical description of the task it is possible to establish analytical relationships that express the independent actions of reconnaissance organs or individual reconnaissance means. Then, having discovered the interrelationships and connections between various reconnaissance organs, it will be necessary to deduce the analytical relationships of the joint actions of the reconnaissance organs. The sum total of these relationships, expressing the actions of individual reconnaissance organs and the connection between them, together with logical connections, represents an analytical model of reconnaissance activity.

The application of this model promises a tremendous saving of time in the process of planning reconnaissance when preparing for combat operations, and during the operations when expanding reconnaissance efforts for the purpose of obtaining the necessary information in time to preempt the enemy.

In order to construct the model cited above and to use it, it is necessary to formalize the reconnaissance process. This can be done if we first of all determine precisely what limitations and assumptions are incorporated into the model, and which data constitute initial (constant) information and which constitute variable information.

Let us examine these questions in greater detail.

Limitations and assumptions. Reconnaissance activity as a whole is a very complex phenomenon. It is affected by an extraordinarily large number of factors, whose comprehensive influence is extremely difficult to measure. All these factors may be conventionally divided into four basic groups: factors exerting a negligible influence and having either a slight or significant probability of occurring, and factors exerting a major influence and recurring either rarely or frequently.

The principle of rejection of nonessential parameters and connections must be assumed as the basis for calculating the limitations and assumptions. It is obvious that in the model of reconnaissance activity it is sufficient to consider only the last two groups of factors, since the first two, although they would produce a certain (though quite insignificant) refinement of the final result of the calculations, will complicate the mathematical model and increase the time needed to make the calculations.

One may assume, for example, that the personnel of reconnaissance subunits and units are on the average trained identically, and that they fulfil their functional duties efficiently, that oversights by the persons assigned to organize and direct reconnaissance activity are insignificant (or nonexistent), that the weather in the reconnaissance area corresponds to average meteorological conditions in the theater of military operations, that during a specific interval of time there exists an abstract equilibrium, and that the tasks, personnel, direction-finding base (for radiotechnical reconnaissance), reserve of reconnaissance forces and means, and the extent to which the enemy has been reconnoitered, all remain unchanged.

The acceptance of these and similar assumptions and limitations can significantly simplify and speed up the solution of problems; this, in our opinion, will not lead to serious errors in assessing the effectiveness of reconnaissance forces and means.

Constant or initial information should include general information about the enemy, our reconnaissance forces and means, and the physical and geographic conditions of the area of combat operations.

Information about the enemy will contain the total strength of his grouping, the number of targets classified according to their importance in the operational-tactical plan, the probable nature of his actions, and also his capabilities for combating our reconnaissance. The entire zone of reconnaissance is broken down into zones of equally probable distribution of targets: the probable number of targets is determined by class in each zone.

Information on reconnaissance forces and means shows how many and which reconnaissance organs (or technical reconnaissance means) can be allocated to fulfil reconnaissance tasks, with what means the reconnaissance organs are equipped, their condition, and the depth or area of each one's actions.

The information on physical and geographic conditions will contain data on average meteorological conditions and radiuses of visibility of the targets, taking terrain relief and the weather into account, and also will contain data on conditions of movement along roads and off of them in this terrain.

Variable information solidifies initial information, taking account of the plan adopted for using reconnaissance forces and means as well as the situation that has developed (changes in the enemy grouping, meteorological conditions, time of day, etc.). It takes into account the allocation of reconnaissance forces and means against targets and sets the overall time in which reconnaissance is to be conducted.

Variable information is grouped on initial data cards which are filled out by reconnaissance officers according to the variants in which the reconnaissance forces and means are used. Filling out these cards takes very little time (one or two minutes). On the basis of repeated machine calculations a choice is made as to the best variant of the allocation of reconnaissance forces and means against the most important targets. As a result, the total amount of time required for planning the reconnaissance is greatly reduced.

A highly important question is that of developing the criteria for assessing the effectiveness of reconnaissance forces and means that was discussed above. It seems to us that the basic criterion, which would not only make it possible to assess the capabilities of each reconnaissance means and determine the effectiveness of a group of similar reconnaissance organs, but would also permit an assessment of the effectiveness of a whole system of heterogeneous reconnaissance forces and means, could be the mathematical expectation of the number of targets detected by a reconnaissance organ (a group of reconnaissance organs or all of the reconnaissance forces and means) in a given time. Such a criterion makes it possible to assess reconnaissance forces and means according to the basic requirement -- their ability to obtain data on the enemy and to detect his installations.

Other criteria, in our view, could be the accuracy in determining the coordinates of a target being reconnoitered, the reliability of the information obtained, and the time required to transmit reconnaissance data and to transfer reconnaissance efforts to a new axis or to a new area. By supplementing the basic criterion they make possible a more thorough assessment of the effectiveness of reconnaissance forces and means.

Let us now examine in greater detail the procedure for using a model of reconnaissance activity, an enlarged block diagram of which is shown in Figure 1.

First of all in Block 1, the choice of reconnaissance organs, the forces and means allocated for reconnaissance and the overall time required to carry it out are determined, and one of the reconnaissance organs is chosen. Then in Block 2 reconnaissance losses are determined, and the moment the reconnaissance organs will be put out of action (if such a threat exists), is calculated. Block 3 seeks the probability of detection, by the given reconnaissance organ, of a target of a given class. The value of the figure obtained makes it possible in Block 4 to determine the number of targets of one class and obtain the mathematical expectation of the number of similar targets (or targets of one type) detected by reconnaissance.

By successively referring to Blocks 3 and 4, the mathematical expectation of the number of targets of each class detected by reconnaissance may be found. This data is easily summarized in Block 5. The mathematical expectation of the number of targets detected by other reconnaissance organs may be determined in the same manner.

An estimate of the joint activity of reconnaissance organs depends on the specific conditions of the situation and the tasks the organs fulfil. Thus when reconnaissance groups operate on independent axes, the total number of targets M_{exp_t} that they reconnoiter is equal to the sum of the targets detected by individual reconnaissance means:

$$M_{exp_t} = M_{exp_1} + M_{exp_2} + \dots + M_{exp_n}.$$

When two reconnaissance organs detect the same target, the probability of detection by at least one of the reconnaissance organs is equal to:

$$P_t = 1 - (1 - p_1)\,(1 - p_2),$$

where p_1 and p_2 are the probabilities of detection of the target by the first and second reconnaissance organs, respectively.

When two reconnaissance organs are operating in one zone and each detects several targets, the total number of targets detected by both reconnaissance organs is the random value X. It lies in an interval limited on the one hand by the number of targets detected by both reconnaissance organs, and on the other by the maximum number of targets detected by one of them:

$$M_{exp_t} = (M_{exp_{1max}} \leq X \leq M_{exp_1} + M_{exp_2}).$$

The relationships resulting from joint activity by reconnaissance organs are shown in Block 6 totaling the results of their work.

The proposed methods make it possible to obtain the following results: the mathematical expectation of the number of targets of the i class detected by the j reconnaissance organ; the mathematical expection of the number of targets of all classes detected by one (j) reconnaissance organ; the mathematical expectation of the number of targets detected by all reconnaissance organs; the average number of targets detected by various reconnaissance organs (simultaneously or consecutively); the average number of targets (or the percentage of the number of targets detected) whose coordinates have been determined with sufficient accuracy; the reliability of the data obtained; the mathematical expectation of the number of reconnaissance organs put out of action; the mathematical expectation of the number of casualties sustained by reconnaissance.

By using these results, it is possible to determine the optimum variant of using available reconnaissance forces and means, the time needed to obtain reconnaissance data by these forces and means, and the number of reconnaissance forces and means needed to obtain certain reconnaissance data in a set time. All this will help achieve an economical expenditure of reconnaissance forces and means, and hence enable the available forces and means to fulfil a greater volume of reconnaissance tasks and increase the possibility of more effectively employing means of destruction.

It is known that an enemy grouping always contains a great many targets, but that they are of varying operational-tactical significance. It is desirable to collect exhaustive data on all classes of targets, but in practice this is very difficult to do. Therefore, it seems to us that, on the basis of results obtained by the proposed methods, it is possible to determine how to use reconnaissance forces and means to obtain data only on the classes of the most important targets, i.e., those that are to be detected first. These include troop and weapons control posts, means of mass destruction, and tank groupings. Having made a timely detection of important targets in an opposing enemy grouping, a decision can quickly be made as to the employment of means of destruction, which is of special importance in the fluid, fast-changing conditions of an operation or battle.

Having determined the most important targets to be detected, and having assessed the capabilities of the reconnaissance forces and means, the optimum variant of using them is chosen. Thus reconnaissance groups of divisions and regiments and combat reconnaissance patrols of battalions can plan missions to detect tactical nuclear means (including nuclear land mines), tank battalions, reserves of brigades and divisions, antitank means, control posts of divisions, and reserves of army corps of the enemy.

Special-purpose army reconnaissance groups are the best suited to reconnaissance of enemy operational-tactical nuclear attack means, army corps reserves and control posts, and field armies.

The detection of battalion and brigade control posts, nuclear means of attack, and the basing of army aviation may be planned for radio reconnaissance in the ultra-shortwave band, while detection of control posts of operational-tactical nuclear means of attack, army corps, divisions, brigades, and tactical aviation is planned for radio reconnaissance in the shortwave band. It is advisable to assign radiotechnical reconnaissance means the tasks of pinpointing the enemy troop grouping, artillery and antitank fire control systems, and radar reconnaissance.

Targets to be reconnoitered are allocated on a similar scale for the reconnaissance means of branch arms and special troops. This meets the requirement for integrated use of reconnaissance forces and means for the purpose of obtaining reliable information about the enemy, and, consequently, more reliable destruction of the enemy with the least expenditure of our fire means.

After determining the mathematical expectation of the number of targets detected, we can obtain the degree to which the enemy has been reconnoitered. It can be taken to be unity if the number of targets detected is such as to enable the command objectively, without significant error, to determine the enemy intention and quickly make a desirable decision to destroy the enemy by fire and plan the effective exploitation by our troops of the results of this destruction.

Calculations made during operational exercises and war games in recent years show that the degree to which the enemy has been reconnoitered may be considered to be equal to unity if not less than 80 percent of the means of mass destruction, 60 percent of the control posts, and 50 percent of the tank battalions have been detected, since when this number of targets have been destroyed, control is disrupted, installations cease to function, and the enemy grouping loses its combat effectiveness.

The great mobility of modern enemy installations enables them often and quickly to move out of the field of reconnaissance visability. Therefore the role of final reconnaissance and periodic observation of their disposition areas has greatly increased.

Mobility may be expressed by the time T_o necessary for a target of size I_o to complete a maneuver over a distance S with a speed of V_m and to prepare for action in a new area T_n1.

$$T_o = \frac{S + I_o}{V_m} + t_n1$$

This mathematical relationship enables us to compare various targets in terms of mobility and determine the periodicity of observation required. The maximum periodicity of observation of a target P_{ob} , must be such as to not permit it to move out of the field of reconnaissance visibility during the time interval between two consecutive observations, and thus leave us in a position to preempt enemy action. It must be less than the difference between the time available to the enemy to prepare for actions (t_{en}), and the total time expended on the reconnaissance (t_r), on transmitting its results (t_i), and on the organization of preemptive destruction (t_{od}):

$$P_{ob} < t_{en} - (t_r + t_i + t_{od}).$$

The required periodicity of observation stands in functional relationship to the time available to the enemy, and also to the time needed by our means for reconnaissance and organization of destruction. It can be expressed by a nomogram graph (Figure 2). By using this graph it is possible to determine the maximum allowable periodicity of observation of any enemy installations (depending on their linear dimensions, speed of movement and status) under any conditions. It also is possible to decide how to use reconnaissance forces and means for this purpose, taking into account their capabilities as determined through the use of high-speed computers.

For example, we have to calculate the periodicity of observation of an enemy column l_{en} 20 kilometers deep and moving at a speed V_{en} equal to 30 kilometers per hour. From point 20 on the axis of the ordinate we draw a horizontal line to the intersection with the straight axis OA, drop a perpendicular to the axis of the abscissa, and find the result -- 40 minutes.

The graph also enables us to solve inverse problems, i.e., makes it possible to determine a rational expenditure of reconnaissance forces and means based on optimum periodicity of observation of the targets, the time required for reconnaissance (final reconnaissance) based on the level of readiness of our means, and also to choose the means of destruction which in a given situation will ensure preemption of the enemy in delivery of a strike.

Let us assume that a commander has to choose the means of destroying (to preempt by 15 minutes) an enemy nuclear subunit which has 55 minutes to prepare for a strike. From point 15 on the axis of the abscissa we draw a vertical line to the intersection with the line "55-55", and from this point we draw a horizontal line to the intersection with the axis of the ordinate; the number "40" shows that the required preemption can be ensured under these conditions by aviation with an approach time of 40 minutes.

These, in our view, are the basic points of the methodology of calculating reconnaissance capabilities. Practical application of this methodology will make it possible to increase the degree of scientific validity in the planning of reconnaissance, shorten the time needed to make the calculations, and enable staff officers to devote more time to creative work.

All this will facilitate active combat against the most important enemy installations, and primarily against his nuclear means of attack.

The development and use of a model of reconnaissance activity will make it possible to apply the results of the calculations in scientific research work. Certain principles contained in the methodology can, in our opinion, be applied also to the creation of a two-sided combined model for calculating the combat capabilities of the troops, taking their reconnaissance capabilities into account.

[redacted]

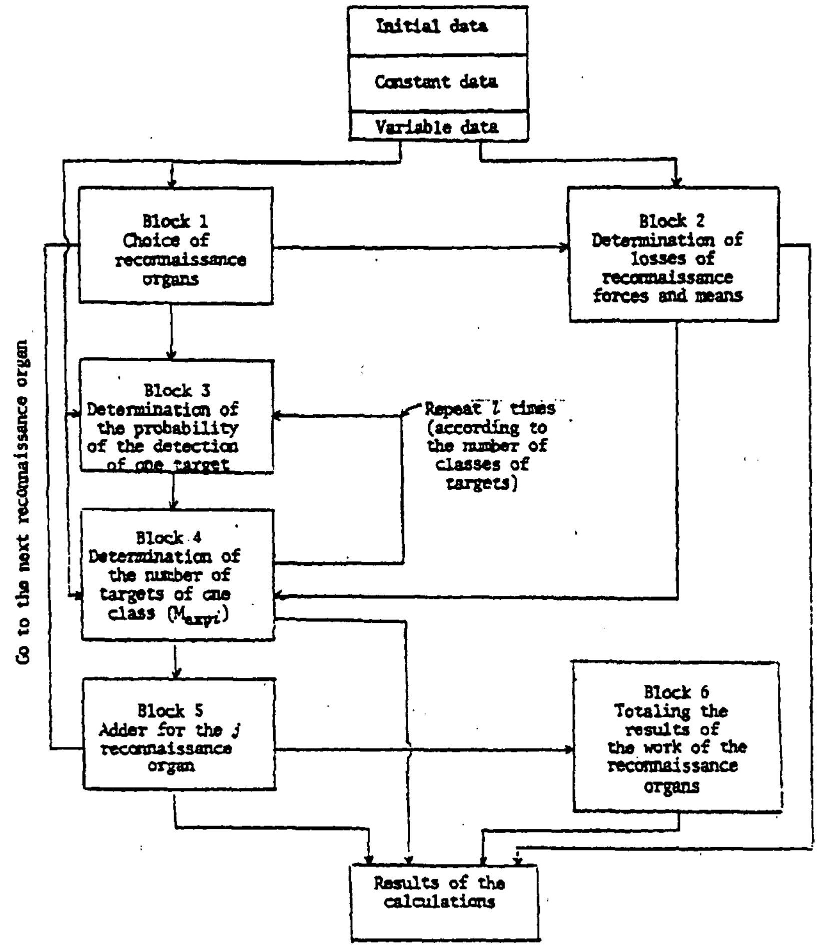

Figure 1
Enlarged block diagram of an analytical model of reconnaissance activity

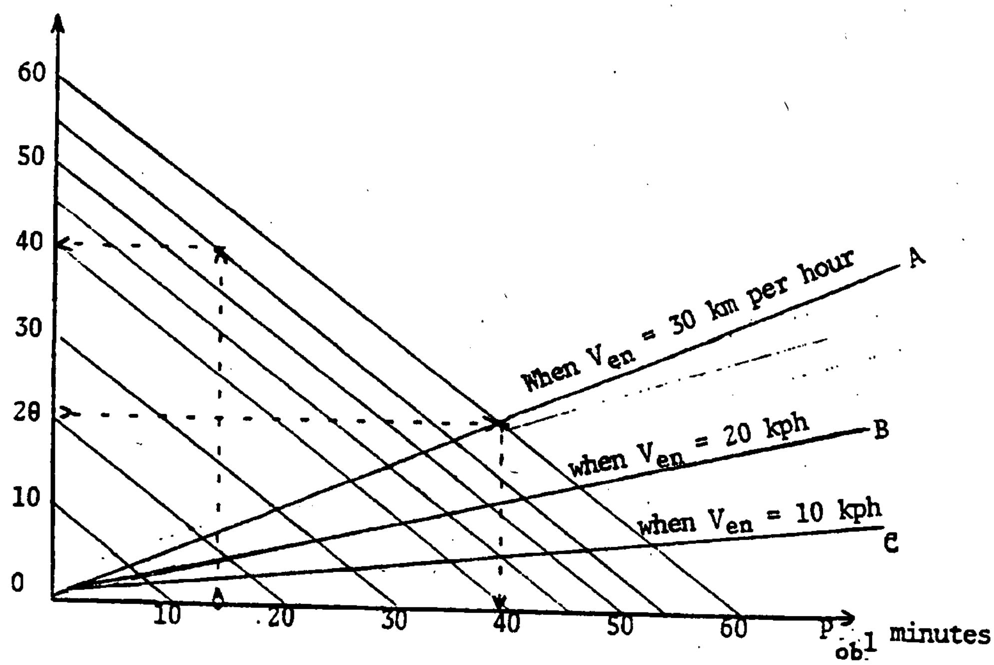

Figure 2
Nomogram graph