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MEMORANDUM FOR: The Director of Central Intelligence

FROM : John N. McMahon
Deputy Director for Operations

SUBJECT : MILITARY THOUGHT (USSR): The Theory of Logical-Mathematical Research of Military Actions

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 on a theoretical and speculative plane the logical-mathematical research of military actions as a means of determining through simulation and algorithms the best methods of organizing, controlling, and using military forces under various standard conditions to accomplish standard military tasks and thus be of great assistance in decision-making. The author opposes the widely-accepted term "operations research" for this activity, advocating instead the term "military actions research." He discusses the direction, aims, tasks, processes, content, and deficiencies of this type of research. This article appeared in Issue No. 1 (71) for 1964.

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

Joe John N. McMahon

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SUBJECT

MILITARY THOUGHT (USSR): The Theory of Logical-Mathematical Research of Military Actions

SOURCE Documentary

Summary:

The following report is a translation from Russian of an article which appeared in Issue No. 1 (71) for 1964 of the SECRET USSR Ministry of Defense publication Collection of Articles of the Journal "Military Thought". This article, written by Rear Admiral K. Zotov, describes on a theoretical and speculative plane the logical-mathematical research of military actions as a means of determining through simulation and algorithms the best methods of organizing, controlling, and using military forces under various standard conditions to accomplish standard military tasks and thus be of great assistance in decision-making. The author opposes the widely-accepted term "operations research" for this activity, advocating instead the term "military actions research." He discusses the direction, aims, tasks, processes, content, and deficiencies of this type of research.

End of Summary

[redacted] Comment:

The SECRET version of Military Thought was published three times annually and was distributed down to the level of division commander. It reportedly ceased publication at the end of 1970,

[redacted]

The Theory of Logical-Mathematical Research of Military Actions

by

Rear Admiral K. ZOTOV

Research of military actions is usually understood to mean the scientific investigation of matters connected with the preparation, conduct, and support of military actions in their technical, tactical, operational, and strategic aspects. The achievements of computer technology have opened rich new possibilities for using a logical-mathematical apparatus to perform such research. However, the use of this apparatus and the corresponding computer technology in researching military actions is still restricted within a well-defined framework. In particular, research has excluded from among its aims those matters which have not yet been subjected to quantitative analysis, including to a substantial degree matters of the moral-political order.

The general aim of this research is to bring to light any objective laws of military affairs and the various factors, both static and especially dynamic, in these affairs.

The research may be conducted in two directions: one is to provide the best methods and ways of using existing forces and means for the fulfilment of the tasks confronting them, under actual, and where possible also specific,* conditions of the situation; the other is to work out the optimal requirements for forces and means that are to be newly created.

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* The statement is sometimes encountered that research of military actions, like that of actions in general, concerns only standard actions. This is, of course, not so, since standard actions interest us only to the extent to which the conclusions from researching them are applicable to specific actions. The degree of specificity, however, must and can be made more precise according to need.

Naturally, it is sometimes difficult to find a clearcut boundary between these individual aims. Moreover, the same methods and ways of calculating, as well as the calculations themselves, can be used simultaneously in different fields.

Each of the individual aims may, in turn, be divided into two parts:

-- establishing the capabilities of any given forces or means; what task can be accomplished by the given forces and means under the specified methods of using them, to include the methods of controlling them, and under the specified conditions; in other words, "what can be done" with the given "what" under the given "how", "where", and "when";

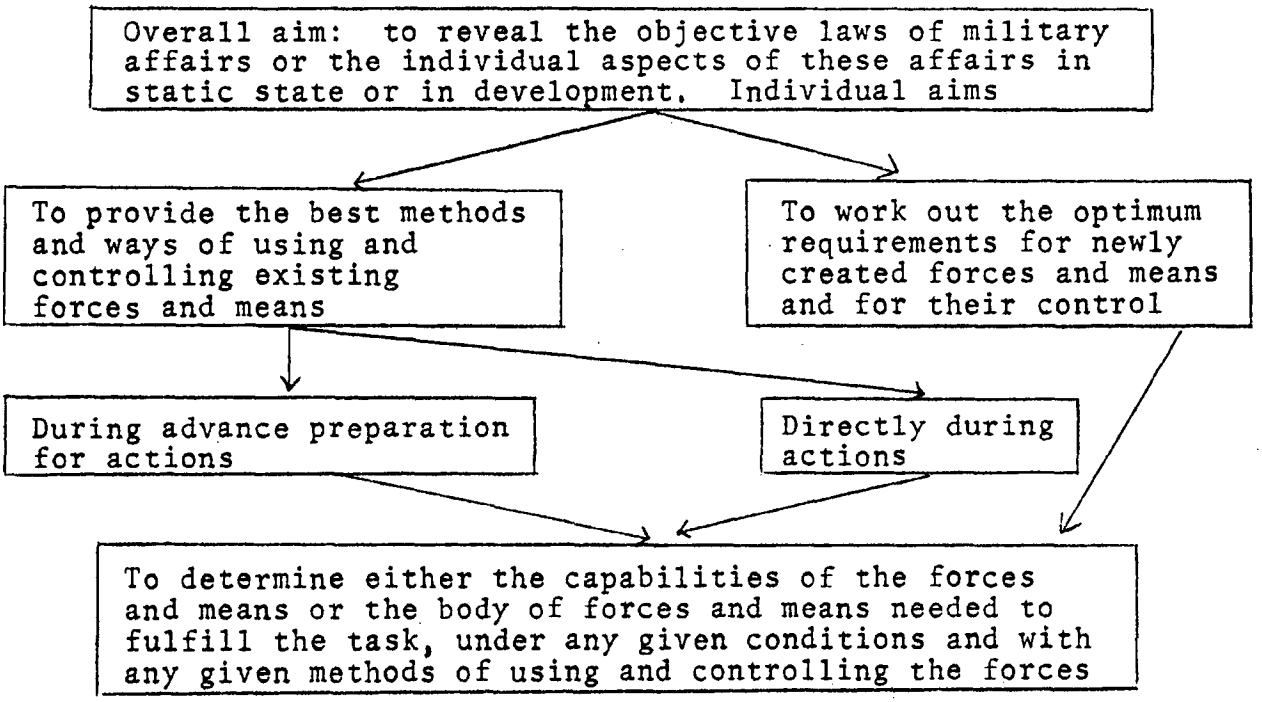
-- determining the body of forces and means required to carry out a given task, the most favorable methods and ways for the forces to take action, and also for controlling them; the most opportune space-time and other (hydrometeorological, etc.) conditions which can in any way affect their methods of accomplishing the assigned task, and the results of its accomplishment.

Any combinations of these questions and source data may arise later. For example, in calculating the body of forces, the situation may compel us to assign a particular place, time, etc., and not the "most convenient" ones.

With regard to the aim of providing the best methods and procedures of using existing forces, it too may be divided into two parts. The first is to provide maximum accuracy and completeness of calculations during the advance preparation for any given actions, including the development of regulations, manuals, etc. The second is to guarantee the necessary speed and all possible precision of calculations during an operation, engagement, or other actions, i.e., in a rapidly changing situation when decisions must be made immediately. The methods and procedures of calculating may also coincide here, but as a rule, in the first instance they will be more extensive and will lead to more precise conclusions, while in the second they will be more curtailed and will lead to

approximate decisions.*

For clarity, the essence of the foregoing may be expressed by means of the following diagram.



Aims of military actions research

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* We sometimes hear it said that this second category does not fit the pattern, and that today exhaustive accuracy (precision) and completeness of calculations must and can be provided not only beforehand but also during the very course of combat, especially of an operation.

If we are speaking of the capabilities of present-day computers with regard to formulated and programmed algorithms, then this is so; but the point here is that actual conditions will always differ, if only insignificantly, from the conditions for which these algorithms and programs were formulated; and if it becomes necessary to obtain rapid replies, we will often have to be satisfied with a certain degree of approximation.

But military actions research is also understood to mean the aggregate of principles and organization, including methods and procedures, i.e., the theory of this scientific, in this case quantitative, examination, whereby the more frequently used words are not the words "military actions research" but the words "operations research".

Let us first come to an understanding with regard to concepts and terms. By the word "research", as it is usually taken, it is desirable to designate either the research process itself or its results, and to use the generally adopted term "theory" to designate the principles and organization of this process. True, we also have such instances as when, for example, "strength of materials" ("sopromat") refers not to this strength itself but to the science devoted to it. But even using abbreviated terminology, it is always necessary to achieve clarity of wording in context.

We shall now consider how advisable it is to use the term "operations research" in military matters. Its protagonists present two arguments in its favor:

-- such a designation for this science, coming to us from abroad where it first began to be formulated, has already taken root in our country, not only in the general civilian sphere, but also in the military sphere;

-- the word "operation", derived from the Latin verb "operare" (to operate), signifies a definite purposefulness, while the word "action" ostensibly does not imply such purposefulness.

As regards the first argument, we have already had occasion to state that if the theory of "operations research" did actually begin to be formulated first abroad as a science under this designation, nevertheless the foundations of this science were already being laid down earlier in our country* in the form of methods for operational-tactical calculations and all sorts of

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* Military Thought No. 8, 1960, page 75.

tactical-technical calculations.* As regards the other argument, the word "action", possessing greater semantic force than the word "operation", is not inferior to it in activeness of connotation.

In the military sphere, the word "actions", more precisely "military actions", is much more suitable than the word "operation", since:

-- the word "operation" has for us a definite, important, and established meaning, which there is no point in disturbing;

-- continuing to acknowledge the generally accepted meaning of the word "operation" (surgical operation, banking operation, etc.), we have adopted still another, third, meaning for this word in the expression "elementary operation" (computer speed is determined by the number of such operations in a unit of time); why add to the confusion by using this word in yet a fourth meaning?**

-- and most important -- military actions research touches on that broad field for which the designation "actions" has long been firmly established, for example strategic, operational-tactical, technical, and all kinds of support actions. The word "actions" has long since acquired this collective meaning for us. Why should we reject the use of this word?

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* Of interest in this connection is the statement of the renowned English scholar J. BERNAL: "Soviet armies, as far as we know, did not have a separate corps for tactical research (in contrast to the US -- K.Z.). They did not need it, since, thanks to their fundamentally excellent class structure and the training and traditions of the Soviet Army, science has from the very beginning been a natural part of its tactical training and combat actions. The achievements of this army both in the production of superior weapons of old and new types -- tanks, guns, and long-range missiles, and in their use on the battlefield, show the degree to which science can be exploited in war, flexibly and with inventiveness." ("Science in the History of Society", translation from the English. Foreign Literature Publishing House, 1956, page 443).

** Even in a fifth, since in logic, for example, operation is understood as the defining of new elements in relation to a selected element or elements.

At the same time, if the research methods in these military fields vary somewhat from one to another, and have their specific features in each individual case, the fundamentals of research on military actions are nevertheless the same for all of these fields, and for this reason it is also most suitable to designate the theory we are examining as the theory of military actions research -- in that narrow meaning of the word which has already been discussed. However, for the individual branches of the armed forces, this general theory can, as it assumes one shade of meaning or another, be called, for example, "theory of actions research for rocket troops, ground forces", etc.*

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Having briefly considered the tasks of the science under discussion, and having clarified its appellation, we shall attempt to establish its interrelations with the other military sciences, first and foremost with military cybernetics.

Military actions research in itself, i.e., the carrying out of such research, is an integral part of all categories of military art and of a number of the other military sciences organically related to them. Taken outside of this context, however, the theory of this research is an obvious part of military cybernetics (the science of controlling forces and combat means), along with its other parts such as the general theory of controlling forces and means, including the theory of automating this control; the theory of military information, i.e. that theoretical specialty which is introduced by military affairs into generally established information theory; and the theory of technical means of automation of control, including the theory of specialized military computers.

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* There is only one justifiable objection to the term "military actions research" (which applies to an equal degree to the term "operations research"): this is that the research of which we are speaking embraces not only actions but also technical and combat means. It is said that a broader and more inclusive term would be "research of military phenomena". One way or the other, our science must settle this question, so that we do not continue to confuse ourselves with inadequate terminology.

Actually, the control of forces, as a process, includes within itself, in all its aspects and whatever the scale, three main links:

-- the collection and processing of information on the enemy's forces and on our own and on the other elements of the situation;
-- the processing of this information, or the performance of calculations as preparation for the command's decision, and the making of the decision itself as the main act of control;
-- the actualization of this decision (transmittal of orders to executors and monitoring of the execution of the orders).

It is precisely this processing of information, which is the preparatory stage of the middle link of control, which requires well-defined organization, methods, and procedures, i.e., a well-defined theory. The latter is thereby subordinated to the basic requirements of control and applies, in its fundamentals, to any and all fields of control, both in the direct military sphere and in the fields associated with it. Indeed, to what science should this theory be related if not to the science or sciences of control, i.e., cybernetics?

This is where matters stood until recent times, when all control, including the preliminary decision and calculations, was both in essence and in organization a single process, based only on the psychophysiological capabilities of the human being. The situation did not change even when the development of science and technology made possible the gradual automation of such control functions as observation and communications, as a result of which they began to be organizationally "self-determinant" but with calculations remaining, as before, a prerogative of the human being. And finally, the situation is not changing even today when technology, in support of human beings, is gradually penetrating into the field of calculation, making it possible on a base of integrated automation to recombine all auxiliary control processes organizationally into a single whole.

Moreover, today, when the integrated automation of the control of forces is gradually being put into practice, this connection of calculations theory with cybernetics may be seen particularly clearly. The essence of this lies in the fact that it is precisely the results of actions research which are

defining the basic theoretical requirements levied on automation equipment, meaning that it must be high-speed, reliable, accurate in its calculations, etc.

At the same time, both the theory of military actions research and military cybernetics as a whole make extensive use of the entire arsenal of methods and procedures from such generally accepted sciences as the general theory of actions (operations) research and cybernetics as a whole. But these military sciences are actually applied offshoots of these generally accepted sciences.

These are the interrelations between the theory of military actions research and cybernetics. But to the same degree that this theory is devoted to military actions research and is therefore obliged to give full consideration to the specific features and requirements of these actions, the theory is also closely connected with the sciences which deal with these actions -- first and foremost with military art and all of its aspects.

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Let us proceed to the content of the theory of military actions research. This content, as is obvious from the foregoing, must include:

a. as a base -- a systematized list of the matters or individual tasks with which this theory must deal, and also instructions regarding the nature, general plan, and degree of detail in the description of these tasks, since only on such a base is it possible to establish the set of required principles, methods, and procedures for the research;

b. a list and logical-mathematical analysis of the feasible and reasonable criteria for determining the effectiveness with which the different typical military tasks are accomplished under standard situational conditions;

c. a list of feasible and worthwhile research methods and procedures with a simple listing of those to be used when only methods and procedures from the civilian sphere are to be employed and with a detailed description of their characteristics if they have been specially developed for military affairs (for example the "theory of search", etc.) or are more or less tailored to military fields;

d. a systematized list of standard military tasks, with an indication of the specific methods of accomplishing them, both "manually" and by machine.

It goes without saying that, like any other science, the theory of logical-mathematical military actions research will grow and develop as long as there will be a practical necessity for it, i.e., in this instance, until the elimination of war as a social phenomenon.

Let us now dwell briefly on each of the listed points.

The list of individual tasks. First and foremost, the degree of task categorization and of completeness in task descriptions depends on the methods to be used in their logical-mathematical resolution. In each instance it is a question of whether a method or a combination of methods has been found or worked out, together with a corresponding apparatus, for solving any given problem in its entirety, or whether such an aggregate of method and apparatus does not yet exist and the problem must therefore be broken down into smaller subproblems for whose solution the methods and apparatus are already available.

Let us take, for example, a large-scale operational problem such as the task of disrupting enemy transportation lines to a given degree in a certain area for a certain period of time. If we are given all necessary situation elements, including the characteristics of the transportation lines (data on the complement of ships, enemy ports, the nature of the movement, etc.), information on our own and enemy forces and means and on possible methods of using them, hydrometeorological data, etc., then it is possible to construct a suitable general logical-mathematical model of this operation. In other words, a gigantic algorithm can be derived, an enormous system of interrelated formulas, a system which, if specific values are substituted for the various quantities, will give us, to one degree or another, an approximate solution of the problem, i.e., the best method of disrupting the transportation lines to the given degree.

True, as of the present time, such a general algorithm will most often be either too approximate, even distorting reality,

or, if we are going to be operating in probability ranges, too indefinite. This is because too many factors will be left out of consideration, and over an extended period of time it is indeed difficult to take them into account, for example such decisive factors as the dependence of the progress of our operation on the enemy's counteractions and on other concomitantly developing operational and strategic processes. This is also because the quantitative values by which we would like to describe any given relative interdependencies among a series of parameters are a priori in the majority of instances and outside of an actual situation can only be applied within the broadest limits.

The same can be said of simulating even such an individual part of an operation as a battle, as well as of the logical-mathematical simulation of any sufficiently large though integrated set of actions taking place in a complicated situation.

What is then to be done? Of course, we must take all possible measures to improve the old methods and develop new ones so that they will encompass, with the greatest possible integration, complex problems of ever larger scale. But before we can acquire such a capability, it will be necessary, as already stated, to categorize these larger problems into a series of individual problems or tasks, the methods of resolving them having already been outlined.

For example, any operation or battle is divided into such basic parts as the deployment of forces, the immediate accomplishment of the operational or combat task, the exploitation of success or retreat from pursuit, and in general, the regrouping of the forces. In view of the fundamentally different situation and individual tasks at each of these stages, the model of each one will obviously differ completely from the others. In most cases, depending on the degree to which methods have been worked out, simulation will require: further categorization of the tasks or problems; their handling in accord with different situation variants, first for homogeneous forces and then for heterogeneous forces; etc.

But if the degree of categorization of tasks depends on the degree to which methods have been worked out, is it perhaps best to begin with the characteristics of the methods and then proceed

to listing the tasks? No. In the close interaction of tasks and methods (and these interacting elements must be taken to include effectiveness criteria as well), tasks do still occupy the forefront. It is their content which determines the most expedient criteria and the set of methods needed for their accomplishment and not vice versa.

This is one side of the question. On the other side, the process of drawing up a list of tasks does not, strictly speaking, require a scrupulous listing of all tasks with all details, the more so since, as research methods are amplified and pefected, the categorization of tasks can or even must change. In drawing up the list of tasks, it is important only that the fundamental ones not be overlooked; and if any given task cannot be accomplished by existing methods, then the work of researching it will itself suggest what new methods must be worked out or how it may best be categorized.

This being the case, what must be the fundamental composition of the "list of tasks" that makes up the initial base for the working out of the methods of accomplishing these tasks?

First and foremost, this list must include all of the standard strategic, operational, tactical, technical (primarily "fire") tasks, as well as support tasks of all kinds, that are presently facing the armed forces as a whole, each of their branches and branch arms, and their formations, large units, and individual subunits or even elements (for example, such weapons platforms as ships and aircraft).

What do we mean here by the term "standard"? Those tasks are considered standard which apply to a standard modern situation. For example, if we are speaking of the Navy's operational tasks, at the present time they include such tasks as actions against the enemy's combat forces, primarily against his missile submarines and aircraft carriers; combat on any kind of transportation lines; and action against enemy shore installations and protection of our own. If the composition of the enemy forces changes, let us say that the importance of aircraft carriers drops in the same way that battleships died out not long ago, the tasks are correspondingly modified; etc. Each of these tasks will be subject to that categorization which will make it possible to use existing research methods for its

accomplishment.

In a real situation, of course -- and it is for this, actually, that all research is conducted -- the accomplishment of each of the standard tasks and its individual parts will be defined specifically and to the very last by substituting in the selected formulas the values for the respective parameters.

We note that in their actual accomplishment, some of the listed operational tasks of the Navy coincide to a certain extent, for example, part of the matters of protecting the coast and the transportation lines and correspondingly, part of the actions against enemy combat forces, etc. It is obviously the same for all branches of forces in most of their fields of activity and in their various stages. But during the actual course of research, identical tasks can be combined, while the complete starting lists of tasks guarantee that none of them will be omitted.

In addition to the above-mentioned "first stage" of standardization of tasks, a "second stage" of standardization is also necessary, dealing no longer with "standard" but with completely abstract situational conditions and actions. We all know, for example, the significance of such a recently developed applied mathematical framework as search theory, which can be used with any situation, forces, and means. True, this theory introduces no fundamentally new methods of search compared with those existing previously. It limits itself only to recommendations as to which are the more favorable conditions and methods for search, and it also gives the probabilities and mathematical expectations of search success for each standard case, and in this lies its usefulness.

As with the task of search, a series of other tasks, to be generalized for all branches of the armed forces, also require such abstract theoretical research:

-- selection of march (flight) route;
-- selection or setting up of a battle formation, in particular methods for the optimal laying out of a defense zone using different forces and means;
-- methods of selecting the axis and the procedure for breaking through a defense;

-- deployment (operational, tactical);
-- allocation of targets;
-- pursuit (including interception);
-- evasion, retreat from pursuit, etc.

Here we are again approaching the realm of methods of accomplishing these tasks, but once again it is necessary first to outline the necessary tasks and then proceed to the methods of accomplishing them.

Of the listed "abstract-standard" tasks, some have already been researched thoroughly enough and by different methods (laying out a defense zone and breaking through one, allocation of targets, and others). But the question here is to proceed from separate projects in these fields to the creation of the integrated pertinent theories. There is no doubt that not only the operational-tactical but also other fields of military affairs require the distinguishing of such tasks.

The creation of lists of tasks for each branch and arm of the forces, and to a certain extent also for the armed forces as a whole, and the subsequent continuous maintenance of these lists in an updated status, consitute one of the important tasks of our scientific organs.

Effectiveness criteria for the accomplishment of standard tasks. It would seem that the question is clear: in all instances, the criterion should be the most economical accomplishment of a task, i.e., performing it with the fewest, and fewest permissible, losses and expenditures on our part. However, there at once arises here a series of individual questions requiring clarification.

The first of them is to interpret to what extent the task must be accomplished when the requirements on extent may vary, for example when destroying enemy forces and means, capturing enemy territory, etc. It may be that destruction of certain forces or installations, of no purpose in a given encounter in the tactical sense, will be important from the operational or strategic viewpoint. Thus, the great losses inflicted by the Soviet Army on the German fascist forces in each of the operations of the Great Patriotic War, perhaps sometimes even exceeding the degree necessary to accomplish any given task, in

the final analysis played an enormous strategic role, leading to the collapse of Germany's military machine. In other words, every task must be assessed from all essential viewpoints, including the aspect of probable future tasks.

The second individual question is to establish the permissible limit of our losses or expenditure of forces and means in accomplishing any given task. It is one thing, for example, to effect a certain degree of destruction of an enemy shore installation with missiles from submarines with minimum losses of submarines, i.e., with minimum penetration into the enemy antisubmarine defense zone; it is another matter to achieve the maximum degree of probability of destroying the installation without regard for losses, i.e., with deep penetration into the antisubmarine defense zone; etc.

A characteristic example in this regard is furnished by the Italo-German sea shipments to North Africa in 1941 and 1942 to reinforce and supply the Axis troops there in their battle with the British. In some months, ship losses on this transportation line reached 50 percent or more, and still the shipments continued, from necessity, while in a less tense situation, even much fewer losses sometimes caused the stoppage of shipments, their transfer to other axes, etc.

Even CLAUSEWITZ, in his work "On War", wrote about both of the criteria under consideration here, i.e., the extent to which the task is accomplished or in a given instance the degree of damage inflicted upon the enemy, and the permissible limit of our own losses. He said that in inflicting losses on the enemy, one of three considerations can be taken as a guide:

-- the extent of the losses which must be inflicted in order to accomplish the task at hand;
-- the greatest possible losses;
-- the inflicting of losses while sparing our own forces.

Today, of course, the methods of using these criteria have become more thorough and more extensive. In particular, there has arisen, or become much more important and acute, a third individual question -- comparing the economic cost of accomplishing any given task using different forces, means, and methods. It is one thing if the situation allows us to use

forces and means of only a certain branch or arm and in a certain combination, but another matter when there may be several such combinations, let alone if there are many. Then a comparison must be made not only of the "costs" of the simple qualitative accomplishment of the task but also of the time, i.e. the degree of speed of this accomplishment by the different methods, the importance of this speed in the anticipated situation, the advisability of pulling in forces from another axis, etc. Circumstances will indicate which of these factors is the most important. But at all times serious concern must also be given to comparing costs, including the military-economic costs, losses, and expenditures -- a factor to which, unfortunately, attention is often not devoted.

This factor is particularly important in strategy, when the military-economic potential of the opposing sides is involved -- whether it is a matter of preparing for war and adopting a decision, or of which branches and arms of forces are most advantageously employed to accomplish any given tasks, or of carrying out large-scale strategic operations right during the war.

An illustrative example is provided by the actions of the German troops against Allied ocean and sea transportation lines in the years 1939 to 1945 -- a large-scale strategic operation or even campaign with the goal of first forcing England out of the war and then severing or disrupting actual US participation in the war. Though difficult, it would be important to compare the total efforts expended by the one side to protect its transportation lines and by the other side to attack them.* But it would be necessary to compare not so much the costs in themselves as the "individual cost items "obtained by breaking these data down into costs expressing the military-economic potential of each of the coalitions as a whole, i.e., the extent of the military-economic efforts applied by one side or the other to the accomplishment of this task; and in addition to take into account the immense set of other political, economic, and military factors which are important in this regard.

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* The first such effort has been made in the collective work "Combat on the Ocean and Sea Lines of Transportation During the Second World War", which will soon be published.

As we can see, in any number of vital cases, we must cope with not one but several criteria, with a set of them, in which, of course, the leading factor or leading factors are to be singled out.

The logical aspect of the possible criteria, which we shall review briefly, must be combined with their mathematization. Inasmuch as almost all military events are, to one extent or another, probable in nature, the basic mathematical framework in this case is the theory of probability, which for these purposes utilizes primarily:

-- either the probability of accomplishing a task, including the guarantee or degree of the certainty of success with the repetition of actions;

-- or the mathematical expectation, providing an estimate of the average likelihood of success and equal to the sum of the products obtained by multiplying the probabilities of the different individual cases by their values.

Apart from conforming to the task which is to be carried out, effectiveness criteria must satisfy two other basic requirements: adequate sensitivity and maximum simplicity, but not, of course, by giving up rigorousness.

Possible and expedient methods and ways of researching military actions. Used for researching military actions are the analytical method, the statistical method, the method of game simulation and of experimental exercises, and most often some combination of these methods.

We shall dwell in greater detail on the analytical method, taking it as an example to illustrate the standard content and process of a research project. In the general case, such a

research project must include the following stages:*

-- formulation of task;
-- selection of evaluation criteria;
-- determination of necessary parameters;
-- collection of data;
-- synchronous formulation of logical-mathematical model (or algorithm);
-- its solution for the given situation (or "optimization");
-- checking of the theoretical conclusions by experiment, if time and other circumstances allow;
-- practical application of the results.

Proper formulation of the task is exceptionally important for the entire course of the research project, directing it along the only correct path and thereby (along with other factors) ensuring not only maximum speed but also maximum economy in obtaining results. The subject matter of likely tasks for research has been examined at the beginning of the article.

We have also dwelt on the matter of criteria.

In determining the parameters of a task, we should keep in mind the need to choose them carefully, in "necessary and sufficient" numbers so as to avoid hampering the research project with questions of little importance but at the same time without overlooking the important ones, selecting those which are the most essential, the most characteristc, and at the same time the most easily mathematized. We must treat with particular carefulness such qualitative factors as the political-morale condition and combat training proficiency of the forces, the art of command, the cohesiveness of combat control, etc., whose conversion into quantitative factors is only partially possible at the present time, primarily on a logical-statistical basis.

The question of collecting data in conformity with the adopted parameters is clear, and so let us dwell on the next stage -- formulating logical-mathematical models or, which is almost the same thing, algorithms.

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* Morskoy Sbornik [Naval Collection] No. 9, 1960, pages 17-18.

A certain distinction between these concepts lies in the fact that we are accustomed to consider simulation more broadly ("physical simulation" etc.), while an algorithm always consists solely in a system of rules; on the other hand, we most often "simulate" processes, i.e. events and their development, although at the same time there are any number of models and statics. However, we can algorithmize any phenomena, static or dynamic.

Without getting into either the essence of the known general logical-mathematical methods such as game theory, queuing theory, etc. or even listing them, we shall note that one of the most complicated problems in simulation or algorithmization is that of combining within the calculating formulas different quantities which are sometimes from very different planes and at first glance cannot be correlated. No less complicated is the problem of optimizing results, particularly when there are a large number of parameters and several criteria.

We shall illustrate these difficulties with an example dating back to the end of the last century. F. JANE, originator of the renowned British ship register, attempted to create a popular naval game. In it the forces of the two sides were supposed to evaluate each other on the basis of "combat coefficients" obtained through fairly arbitrary arithmetical operations on such quantities as the number and caliber of guns, thickness of armor, ship speed, etc. Clearly, nothing serious could come of such a primitive undertaking. But does this discredit the idea?

No. The point is to find, by means of penetrating analysis, the logical-mathematical correlations, even if only probabilistic, that conform to reality between any given quantities. In other words, to correctly simulate an event. Specifically, a good example of this is the long-established formula for "artillery weapons power", which combines by multiplication signs such at first glance different quantities as the rate of fire, accuracy, and destructive power of artillery. Indeed, it suffices to increase or decrease any of these factors severalfold (even to making it zero) in order to increase or decrease the product by the same power.

If we go from weapons to tactics, which combine fire and maneuver, then an excellent example of such a model for the 20's

and 30's of our century could be provided by the "tactical diagrams" of S. P. STAVITSKIY, by means of which it is possible, on the basis of a methodically correct mutual comparison of the indicated quantities (number of guns, thickness of armor, battle range, course angles, etc.), to arrive at precise conclusions on the best firing station in an artillery battle and on when to take up the station and when to retain it. Thus, for example, these diagrams, prepared after the fact for the English and German battle cruisers of World War I time, immediately provided an unmistakable answer regarding the reason for the losses of BEATTY's cruisers in their clash with HIPPER's cruisers: the reason was the grossly erroneous choice of battle range by the English. Modern computer technology would easily have made it possible to automate the performance of such calculations and the obtaining of the required recommendations.

Thus, broad launching of work to find quantitative characteristics for the various qualitative phenomena of military affairs in all of their fundamental aspects, with a search for the best standard and also special methods of establishing logical-mathematical relations among these quantitative factors -- this is the fundamental way of developing a theory of military actions research.

What is particularly important and difficult is that these relations must be established, particularly in the tactical, operational, and strategic aspects, not statically but dynamically, i.e. taking into account the time progression of the development both of our own actions and of enemy counteractions and also the results (with regard to losses, expenditure of combat reserves, etc.). If we are speaking, for example, of tactics, then it is one thing when we are confronted with a one-time action without enemy opposition, let us say an undetected submarine attack on a target, but another matter when secrecy is lost and the enemy begins to take evasive action and moreover to put up opposition, at which time we are required to calculate who could be the first to employ weapons and in what way; and a third matter when repetitive action weapons are being used, for example missiles and even more so, artillery; and a fourth matter when one of the sides or both sides are using varied forms of weapons in different combinations; etc., etc.

Modern methods of actions research have already taken a great step forward as compared with the so-called Lanchester equations, proposed in 1915 to ascertain the effects of a strike but without taking maneuvering into account. Well known in this field is the latest work of Doctor of Technical Sciences I. Ya DINER (Order of Lenin Naval Academy). Recently researchers from the Military Air Engineering Academy i/n Zhukovskiy (Professor Ye. S. VENTTSEL and others) proposed a method for simultaneous analysis of fire and maneuver combined, as yet, of course, in the simplest conditions. This method is now developing rapidly, moreover in several military science organs simultaneously. And there is no doubt that new successes will be achieved in this direction in the very near future.

Serious researching of large-scale problems requires that the enumerated methods be applied interactively. The nature and sequence of the interaction in each case must derive from the specifics of the problem, but as a rule it must be constructed on the general principle of conscious progression: from the practical to the abstract and from the abstract back to the practical but this time on a higher level. Observing reality (actual military reality or in its absence training reality) and when necessary conducting supplementary experimental exercises and research games, we evaluate facts, prepare the necessary analysis taking them into account, and when possible, test the resulting conclusions again in actual practice.

The scope of this article does not allow us to dwell in greater detail on the question of methods and procedures of military actions research, so we shall limit ourselves to the foregoing.

A few words about the final category of the theory of this research, the systematic listing of the standard military tasks, not simply enumerating the tasks as in the first category, but indicating the methods of accomplishing them.

Of course, as a result of research conducted according to a well defined system by the scientific organs of all the branches of the armed forces in all fields of military affairs, we must have exhaustive collections of solutions for all standard problems. But these libraries and collections, which may sometimes be different for combat and training needs, deal no

longer with theory but with the results of the research itself, i.e. as noted, they must constitute the applied aspect of military art and of the other sciences. Moreover, in these libraries and collections the problem solutions can and must be deposited only in the form most convenient for practical use.

But the systematized list of which we are speaking must include within itself the standard as well as the quite abstract tasks, however with exhaustive indications on the methods of handling any of them, so that in the future they can serve as a basic methodology manual when accomplishing specific tasks, including their algorithmization.

This, in brief, in our opinion, is the way matters stand with the fundamentals of the theory of military actions research. As we see, this system of knowledge has its own well defined subject -- the logical-mathematical research in and of itself of these important and diverse actions, and its own system of methods, partly of general applicability but in each case having a distinctively military character, and partly of specific application, applicable for solving military problems only. Thus, this system of knowledge represents a well defined science.

This science, as part of the general science of controlling forces and means, is closely affiliated with military art and with all other military sciences, for which it serves as a research tool. At the same time, it constitutes one of the applied aspects of such a general science as the theory of actions ("operations") research in general.

This science is assuming form and substance before our very eyes. Its subject, task, and content are still not precisely defined. The present article is only one of the attempts to do this. But all military researchers are already feeling the urgent need to systematize and consolidate the principles, methods, rules, and procedures which they have to use in their practical work. Attempts at such consolidation are already being made; for example, in 1961 the Military Air Engineering Academy i/n Zhukovskiy issued a textbook by four authors.* Such textbooks are also being written in other military academies -- i.e., the

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* Ye. S. VENTTSEL, Ya. M. LIKHTEROV, Yu. G. MILSRAM, I. V. KHUDAKOV. Fundamentals of Combat Effectiveness and Operations Research, Publishing House of the Military Air Engineering Academy i/n Zhukovskiy, 1961.

acute need for them is being felt.

It must be noted that to date, both in the teaching of this subject and in the courses which have been developed on it, an obvious leaning toward weapons ("effectiveness of combat means") is taking place, i.e., a tactical-technical deviation, while the operational-tactical aspect of the theory has been and is being poorly developed as of the present time. This is explained to a considerable degree by the still inadequate level of logical-mathematical training of the principal scientific personnel, operations officers, and tacticians.

In this connection, the important question has long since arisen of who is to become engaged in military actions research: whether it is to be primarily civilian scientists to whom military consultants are, as it were, "attached", as is the practice in the US, or to be military specialists, as has been the practice in our country when researching such tactical-technical fields as firing.

There can be only one answer, and it is confirmed by all of our previous experience, including the development of a theory of firing: penetrating research in any field of military (or any other) affairs can be done only by specialists in those affairs. But these specialists must also have an excellent mastery of the necessary logical-mathematical apparatus. "Integrated" specialists, as they are called, are gradually being produced in our country. Naturally, if some of our civilian mathematicians become proficient specialists in military affairs, this can only be welcomed.

At the same time, the overwhelming majority of military specialists will be able to master and utilize the mathematical apparatus only within the confines of actual practice. The development of a mathematical theory proper, including one within the applied fields, will always remain the prerogative of specialists-mathematicians, although in individual cases military personnel have become such specialists. In particular, the thorough working out of a mathematical apparatus for the solution of the most abstract problems of military theory, examples of which have been given above, constitutes an honorable and responsible task for specialists-mathematicians.

The terminology of the new science also needs development. Thus, in the title of the referenced textbook published by the Academy i/n Zhukovskiy, an inaccuracy has been committed: matters of "combat effect" are a part of military actions ("operations") research, and it is therefore improper to link the two terms with the conjunction "and".

And so the new science is developing intensively and on the whole successfully in our country, although as yet without a directing center in the individual scientific organs, academies, and institutes. As a result we see duplication of effort, and conversely some vital new problems are are being ignored. It is necessary that one of the organs named, most preferably Central Scientific Research Institute No. 27, become as rapidly as possible the main scientific organ of the Ministry of Defense in this regard.

We should likewise centralize as rapidly as possible the overall direction of such a, without exaggeration, key matter as carrying out military actions research in actual practice -- both in the individual branches of the Armed Forces and in the Armed Forces as a whole.