Modeling Complexes of Organizational Management Automated Systems - a Means to Overcome the Management Crisis

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Abstract. The modern management crisis is associated with insufficiently quick adaptation of organizational management existing institutional systems to changes in management concepts and paradigms, and with the mismatch of the mathematical models and decision-making methods used in the actual complexity of real controlled processes. Currently, many scientific organizations are conducting research on the creation of such automated control systems that would allow them to be restructured as widely as possible and as quickly as possible, while ensuring an acceptable level of complexity (dimension) of management tasks. IPRI also conducts such studies. At the same time, as a working toolkit, a special design environment is used. It called the modeling complex of the control system. Using this toolkit, it is convenient to develop modern automated systems of organizational management within the framework of the established management concept. A change of concept makes you change the original design. The difficulty of making changes is great enough, which slows down the system to practical implementation. The authors investigated the possibilities and suggested areas of scientific research on the development of the theory of designing organizational management systems that would be adapted to rapid conceptual changes in automated forms of activity. The article presents theoretical results obtained for the design of organizational management systems for aviation and marine forces. Shown are the needs for further development of the available results, taking into account the expansion of tactical standards for the use of forces. Formulated research tasks on the development of existing results based on the methodology of conceptual design of systems and networks tensor analysis.

Keywords: Organization, Organizational Management, Modeling Complex, Control System, Force Management, Conceptual Design, Construct, Tensor Analysis.

1 Crisis of management

The modern world is experiencing another crisis of its development. In many ways, this manifests itself as a managerial crisis, which manifests itself in the form of: misallocation of resources, setting inappropriate goals, improper use of production forces, slow response to changing conditions, lack of demand for many management functions in the absence of management functions that take into account modern socio-economic trends and phenomena. All this leads to the fact that we are increasingly hearing about the excess billions of the population of planet Earth, about starving countries, about the crisis of overproduction, about increasing national debt, about stagnating and depressing national economies.

These phenomena are global in nature, with varying degrees of severity, they appear in all countries, not only in Ukraine. The reason for this is the discrepancy between modern economic management systems and the rapidly changing technological structure. The created management institutes (organizations), the procedural rules used by them, quickly become obsolete, ceasing to correspond to reality. Now, the average specialist, in order to meet the requirements of the time, needs to periodically once every five to seven years substantially review and supplement his knowledge of the profession or even change the profession. Those who do not do this, are forced to move to the periphery in their field of professional activity, lose their social status. The same can be said of organizations. Created to solve specific problems [1], they must undergo permanent reform in the sense of revising (expanding) the forms of activity used and even changing the very concept of their creation. Countries that neglect such an adaptation of their organizational management systems lose their subjectivity (sovereignty) and plunge their population into many disasters.

The forms of inconsistency of existing systems of organizational management with the nature and complexity of managed processes are very diverse. In [2], this is described by the example of the problem of insufficient efficiency of the process control system for the development of aviation forces of Ukraine. The authors have shown that management problems here include:

- resource-target imbalance of development programs or, otherwise, the gap between strategic development goals and private development programs of individual components of forces;
- difficulty in maneuvering resources when adjusting development programs, lack of control over the development processes of aviation forces, as well as inefficient implementation (ignoring) of individual component development tasks due to inconsistency of business interests of industrial enterprises and aircraft development goals.

Problems of organizational management of the processes of the application of armed forces are discussed in [3]. It is noted that the rapidly changing situation in the conduct of hostilities leads to an acute shortage of time to coordinate the actions of forces when adjusting a previously adopted decision. The old approaches do not allow coordinated maneuvering by forces, falling within such a limited time frame. Force efficiency drops.

Academicians V.S. Nemchinov [4] and V. M. Glushkov [5] also emphasized that organizational management systems are characterized by a very large dimension of decision-making space. This is due to the multiplicity of characteristics of the utility function, as well as the multiplicity of aspects of the interpretation of the results. For this reason, it was not possible to create an automated state management system using the concept of target-oriented planning based on the decomposition of optimization problems. The problem of the formation of an optimality criterion and the correct aggregation of large-dimension data has not been solved. The created methods and models for automating organizational management functions did not allow us to reflect the complexity of real processes in their entirety, sufficient for the practice of managing large organizations.

Thus, the management crisis is explained by the extremely high complexity of organizational management processes, requiring the expansion of the widespread concept of target program and optimization approaches, as well as the acceleration of social processes requiring accelerated restructuring of management systems. A natural way out of this situation is the further expansion of the scope of application of management automation, with a comprehensive coverage of organizational management functions, [6] and subject to an improvement in the theory of design of such systems [7]. That is, the problem of improving the methods of designing organizational management systems that are adequate to modern conditions and the complexity of management objects is becoming particularly acute, its solution is an actual scientific task.

2 Modeling complexes - as a means of designing effective organizational management systems

Currently, research organizations (including the Institute for Information Registration Problems (IPRI)) involved in the design of automated control systems have gained widespread research and design, which is carried out as part of the development of modeling complexes of automated control systems for various purposes.

A computer modeling complex with appropriate tools, as noted in [8], is an environment for developing organizational management systems, modeling management processes and solving automation problems for these processes. Modeling systems make it possible to monitor in real time the dynamics of control, analyze decision-making processes and other procedures. The use of modeling systems is advisable not only from an economic point of view, since they, in fact, are simulators, but without alternative in areas associated with great risks to the safety of people, the natural and artificial environment (military, space, energy).

Up to now, a number of prospecting and development work has been carried out in IPRI to create the following modeling complexes:

- monitoring of air, surface and ground space [9];
- automated control system for the aviation complex [8];
- command control system for ship carrier connection (under completion).

Summing up the work done in terms of creating the theory of designing organizational management systems, it should be noted that the following results were obtained in the framework of the projects listed.

First, the subject area of aviation and naval forces control was described. The description is made in the form of a system of concepts, relationships between them, relationships between sets (frames) of concepts. The description of the subject area was recorded in the form of a textual description of the controlled processes and logical models of the databases of modeling complexes.

A system of initial data is described, which is necessary for carrying out operational calculations when planning the use of forces and during operational control of forces and means during their use. Such data, for example, include:

- performance characteristics of weapons and equipment;
- data on calculating the range and duration of flight of aircraft;
- data on calculating the effectiveness of the use of aviation weapons;
- data on the calculation of the area of destruction of anti-aircraft missile systems;
- data on the calculation of the range of radio systems and complexes;
- data on calculating the range of sonar.

Secondly, information objects are formed that are the result of information transformations in the organizational forces control system. It:

- plan for the use of forces and means;
- operational management commands.

These objects have a complex structure and consist of hierarchically nested information elements of different detail levels. So, the plan for the use (Fig. 1) consists of separate tactical tasks (actions) that have logical-temporal connections with other actions and are personified with respect to units (subunits), tactical groups, single ships, planes from the force grouping. Tactical tasks (actions) consist of tactical and technical actions that form links with other tactical and technical actions and are personified with respect to combat crews, crews, individual means, systems, aircraft. Tactical and technical actions are presented as a set of technical actions attributable to individual units, systems, complexes. Each information element from the composition of the application plan is characterized by a certain system of numerical metrics, with the help of which the order, time, place and volume of the use of forces and means are determined.

The information elements of the application plan can be characterized not by one, but by several variants of combinations of values of the corresponding lists of numerical metrics. The set of options for the implementation of the planned tactical, tactical, technical and technical actions is presented in the form of a structural table of actions (table. 1). Otherwise, this table is also called a tensor or decision matrix [10], [11].

The structural table of actions (table. 1) contains:

- names of tactical, tactical-technical and technical actions;
- information about the actions, the implementation of which precedes the beginning (is a condition for the beginning) of the viewed action;
- action option index;
- the values of the parameters characterizing the considered embodiment of the action. As such parameters, various temporal, spatial, and other characteristics can be considered that determine the order of the use of forces and means, the effectiveness achieved (feedback characteristic), as well as information about the personification of actions (who performs it, with the help of which).

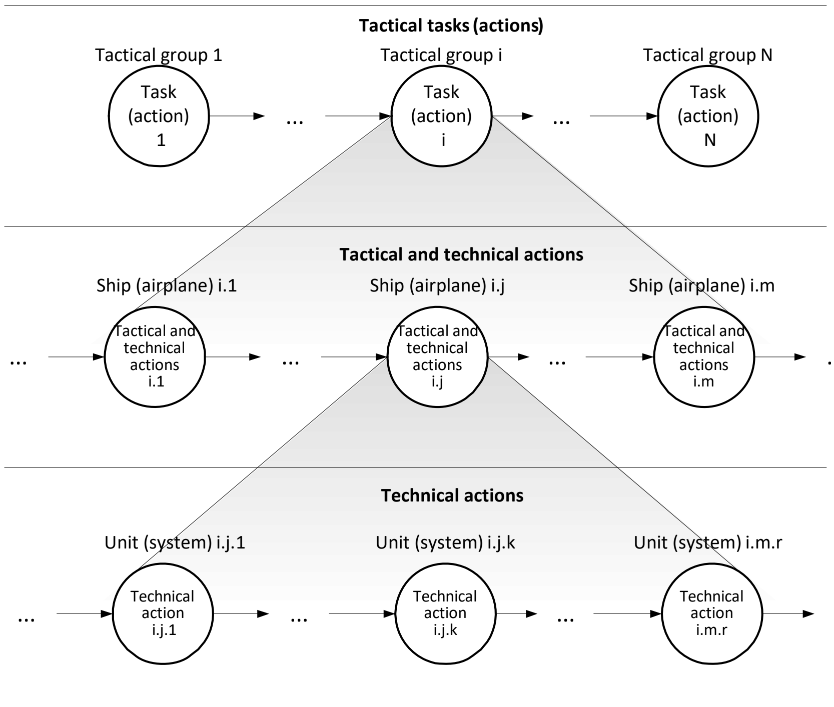

Fig. 1. The structure of information elements representing the plan for the use of forces and means.

Table 1. Structural action table (decision tensor).

Name of action	Predecessor actions	Case	Parameters of actions			
			x_1	x_2	x_3	x_4 …
Tactical action №1	-	case №1.1	$x_{1,1,1}$	-	-	-
- Tactical action 1.1	-	case №1.1.1	-	$x_{2,1,1,1}$	-	-
- Tactical action 1.2	1.1	case №1.2.1	-	-	$x_{3,1,2,1}$	-
		case №1.2.2	-	-	$x_{3,1,2,2}$	-
Tactical action №2	1	case №2.1	-	-	-	$x_{4,2,1}$
…	…	…	…	…	…	…

Thirdly, a multidimensional approach to decision making on a variational network of large dimension is proposed. At its core, the structural table of actions is a network with varying connections between the nodes of this network (tactical, tactical-technical and technical actions) and varying personalization relationships (distribution of tasks between performers). When deciding on the use of forces from the set of possible networks connecting the elements of the plan, one or more options for network diagrams of the sequence and order of actions of the forces are selected. The choice of solution options is based on the ordering of options for performing actions according to the input sets of particular criteria that are defined on the set of characteristics of actions

$$K_i = K_i(x_1, x_2, ..., x_N), \; i = 1, ..., M, \tag{1}$$

where K_i – particular decision-making criterion; M - the number of particular criteria taken into account.

The choice of a particular set of particular criteria depends on the aspects of force control:

- the nature of the strategy (contrition, exhaustion);
- nature of actions (defensive, offensive);
- the type of tasks (air defense, anti-submarine defense, support for ground forces, and so on).

It should be noted that the many characteristics of actions $\mathbf{X} = \{x_j\}$, given the variety of forms of application of forces and means, as well as the multiplicity of aspects considered in decision-making, should be quite large. Therefore, the task of ordering options when making decisions to use of the forces is not trivial.

Fourth, an approach is proposed for the formation of teams of operational command and control of forces on the set of elements of the decision-making tensor. The operational management teams are personified fragments of the action schedule chosen when making decisions to use of the forces

$$\Psi_s = pl_s(\mathbf{X}_s + \Delta\mathbf{X}_s), \; pl_s \in Pl(\mathbf{X}), \; \mathbf{X}_s \in \mathbf{X}, \; s = 1, ..., S, \tag{2}$$

where Ψ_s is the command for the s-th executor; pl_s - a fragment of the plan, personified in relation to the executor; $\mathbf{X}_s$ - a bunch of characteristics related to the actions that are included in the fragment of the plan; $\Delta\mathbf{X}_s$ - changes in the characteristics of the actions being considered; $Pl(\mathbf{X})$ - used decision plan in the operational management of forces; S is the quantity of executors.

Change action characteristics is carried out in accordance with the current situation, taking into account the actual state of their forces and equipment.

Fifth, options for procedural procedures for conducting operational calculations were developed when planning the actions of forces and in managing them during use. As a result of performing the procedures prescribed in the regulations, at the planning stage, a structural table of action options is formed with the established values of the characteristics of the actions and the relationships between them, otherwise - the decision-making tensor. At the operational management stage, a fragment of the structural table is selected and the values of the characteristics of the elements in the selected fragment are adjusted. In fact, the proposed procedural regulation is a sequence of conducting operational-tactical calculations in the hierarchy of power control bodies. In the planning mode, the sequence chart for solving functional problems has the form of a global search algorithm for a rational (optimal) solution on a set of action characteristics. In Fig. 2 shows an example of such a graph for the case of preparing the initial data for making a decision on the use of naval forces in solving reconnaissance tasks. In the operational control mode, the schedule for solving functional problems has the form of a follow-up circuit. In the figure, the calculation procedures are shown as rectangles with numbers. These rectangles are the vertices of the network diagram. The sequence of calculations is determined using the edges of the network diagram. The essence of the calculations performed using separate procedures or their groups is represented using callouts.

The process of solving functional problems in the conversion of management information, being distributed among various decision-making bodies (nodes), is implemented in the modeling complex using the dispatch procedure. In Fig. 2, for example, dispatching tasks are procedures numbered 5 and 18. The dispatching procedure allows you to create a single information and functional space for those involved in the decision. Their work when using automation tools, for example, in planning mode, looks like the process of filling out several options for the commander's map, onto which additional elements of the situation and planned actions of the forces are sequentially applied (Fig. 3).

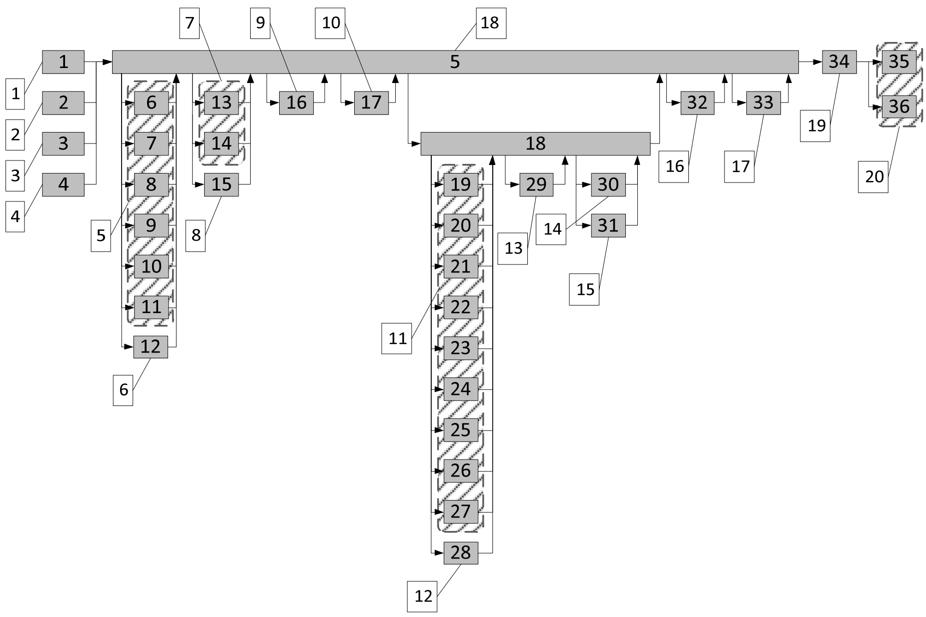

Fig. 2. The sequence of solving functional problems of the special software of the modeling complex when preparing data for decision-making at the planning stage.

The following groups of procedures are indicated in the figure:
1 – Adversary Information;
2 – Operational Directive, disposition;
3 – Own Force Information;
4 – Interacting Force Information;
5 – Composition and basing of the enemy, his targets and goals;
6 – Composition, basing and condition of interacting forces;
7 – Enemy capabilities to solve reconnaissance and electronic warfare (EW) tasks;
8 – Interacting Force Capabilities;
9 – Evaluation of enemy EW methods;
10 – Enemy EW Options;
11 – Assessment of the situation for reconnaissance;
12 – State and readiness of reconnaissance forces and means (ships);
13 – Assessment of capabilities of reconnaissance forces and means (ships);
14 – Options for using shipborne reconnaissance equipment;
15 – Variants of application of radio engineering ship intelligence tools;
16 – Formation of a network diagram of the sequence of actions;
17 – Intelligence Plan Formation;
18 – Dispatching calculations and making decisions on combat support;
19 – Formation of a "paper" version of the Intelligence Plan;
20 – Formation of orders.

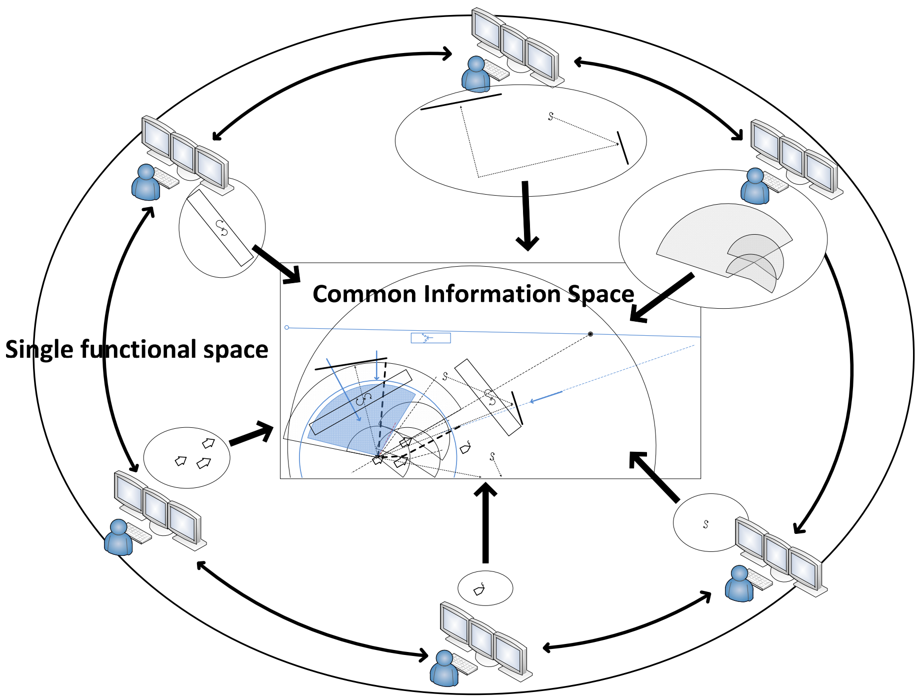

Fig. 3. Automated distributed decision making mechanism.

The designed system of organizational management of forces operates as follows. At the planning stage, the decision maker (commander) forms the plan for the use of forces subordinate to him. The strategy looks like a certain sequence of accomplishment of enlarged tactical tasks, defined in time, space, and assigned to the corresponding performers (organizational-staff formations). The formed plan is put in line with a certain variant of the enemy's actions and the conditions for the use of forces. The system identifies episodes corresponding to various aspects of management from the announced plan of application. The classification of episodes occurs in such a way that they form a simple sequence in time (at any moment in time, belonging to the period of application of forces, only one episode is worked out). For example, in Fig. 4 shows the sequence of episodes of the design of the use of naval forces in the defeat of enemy naval assault forces. These are: an episode of leaving the point of permanent deployment and building a marching order; the episode of the transition to the tactical deployment area and the episode of the deployment of forces in battle formation and the application of a comprehensive fire defeat to the enemy.

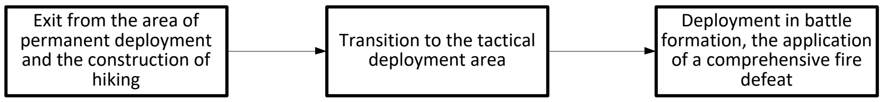

Fig. 4. Episodes of the use of force.

For each episode of the use of forces, when preparing data into the decision of the commander, a specific procedure for converting information by solving functional problems of special software of the modeling complex is characteristic. This order is determined by the aspect of force control. The system determines this aspect and sets the sequence of calculations in accordance with the episode in question. Within the framework of the established procedure for performing calculations, their variability is regulated and, thereby, a space is created for decision-making.

Based on the calculation results, the structural table of actions (decision-making tensor) is filled. The tensor is filled using the dynamic programming method in accordance with the Bellman scheme. First, the functional tasks are solved for the episode of the application of complex fire destruction (third episode). Then, taking into account the characteristics calculated for the third episode, the decision-making tensor is supplemented with data related to the episode of transition to the tactical deployment area (second episode). Further, the calculations are performed for the episode of exiting the permanent deployment point (first episode), but taking into account the data calculated for the second and third episodes of application.

When making a decision, the principle of dynamic programming is also used. First, on the basis of a multitude of options for actions related to the application of complex fire destruction, using a group of particular criteria, one or several options for the use of forces are selected. Further, for each variant of the application of complex fire destruction, one or several transition options are selected. To select transition options, a group of particular criteria is used, covering the corresponding aspect of management.

The exit options from the permanent deployment point are selected for the established transition options when using the specified particular criteria.

Such a reduced set of options for the use of force is used for subsequent analysis and final decision making by the commander.

At the stage of operational control of the use of forces, the situation is monitored for the situation (weather conditions, enemy actions, the state of their forces) for their compliance with the decision. In case of inconsistencies, adjustments are made to the parameters of the order of application of forces and means. With a significant discrepancy between the plan and the situation, the decision is adjusted using the previously formed decision tensor. Changes to the plan are made taking into account the actual situation.

3 Unresolved problems and current directions for further research

As can be seen from the presented results of the design of modeling complexes, in IPRI certain results have been achieved in building the theory of designing organizational management systems.

The main theoretical result is the development of a method for forming the decision tensor (structural table of actions). The result obtained includes:

- determination of the form of the structural table;
- formalization of the elements of the structural table in the form of tactical, tactical, technical and technical actions, characterized by sets of numerical metrics and logical-temporal relationships;
- the sequence of calculations to determine the values of numerical action metrics filling out the structural table;
- synthesis of a sequence of complex calculations in the formation of a structural table for multi-aspect control of forces;
- methods of multidimensional decision-making on the use of forces on the basis of a structural table of actions of large dimension;
- a mechanism for controlling the process of solving functional problems that implements the principle of distributed decision making.

However, the above is far from completely exhausting the solution of the problem of constructing an effective theory of designing systems of organizational control of forces adapted to overcome the modern crisis of control (the complexity of the control object and adaptation of the control system to rapidly changing conditions). What are the scientific tasks that need to be solved in this area in order to get closer to the desired solution to the identified problem, based on today's ideas and knowledge in this area?

When designing any organizational management system, you have to create the following basic elements (Fig. 5):

- a system of concepts or a model of a system;
- a system of axioms or initial data for the regulation of the functioning of the system;

— a system of procedures that is implemented during the operation of the control object and in the control system itself.

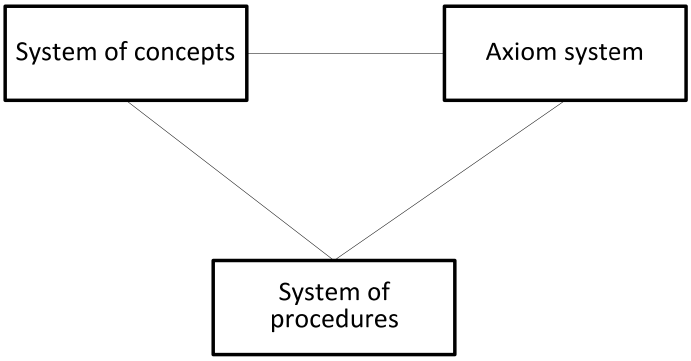

Fig. 5. The constituent elements of a typical project of organizational management system.

These elements, upon completion of the project, gain integrity. This integrity takes the form of either a cognitive or ontological network of activity.

In the presented results, which were obtained in the framework of the design of modeling complexes of automated control systems for the aircraft complex and ship connection, the concept system (system model) exists in the form of a description of control processes, as well as a logical database model, including the decision-making tensor. The system of axioms is presented in the form of regulations on the tactics of the use of forces, as well as a source data system, based on which operational calculations are made during the planning and operational control of forces. Tactical norms are present in the form of settings for the calculation algorithms, and the initial data are entered directly into the database of the modeling complex. The system of procedures is the tactical, tactical, technical and technical actions of the forces, as well as settlement tasks to determine the characteristics of these actions, linked to a logical network.

Based on the design results, the developed automated force management system is corporate. In other words, it is unique and applicable only to control specific forces. In determining the concept of building a system, the accumulated experience of using and controlling forces of the corresponding type was used to a large extent, as well as the methods of system analysis and mathematical modeling. The created organizational management system is adequate to the current level of complexity of the management object, that is, it is effective. If you supplement the lists of concepts used, introduce new tactical standards, change or expand the concept of force control, the designed system will lose its effectiveness if you do not make the appropriate settings in the software. Changes made to any element of the software (to the system of procedures) are most likely to affect other elements. Changes to these new items will affect the following pieces of software. So on an increasing, exponentially, the difficulty of modernizing the initial project will grow. In addition, multiple upgrades can lead to conflicting changes. To compensate for the contradictions, it will be necessary to introduce additional information processing loops. In the end, under the weight of internal problems, the old project will "die" because it will be easier to start a new project "from scratch" than to make corrections to the existing system.

It is possible that one could put up with this state of affairs. In any case, the developers are guaranteed to have a permanent job. However, such a mode of permanent project support is not always possible. For example, when working with a foreign customer, the organization of this kind of work is fraught with great difficulties in implementing interstate cooperation and is fraught with image losses for the developer.

In this connection, speaking about the further development of the theory of designing organizational systems to forces control, methods of consistent changes in the procedures system (software), when changing the concepts system and the axioms system, would be nice to get. That is, for example, a new type of weapon was adopted, which to a large extent differs in capabilities from the means taken into account when developing the design tasks. The use of new weapons expands the tactics of the use of forces. For the current state of design theory, in order to take into account the factor of the emergence of a new type of weapon, it is necessary to significantly supplement and adjust the system of calculation tasks to determine the numerical metrics of the planned actions. If there are methods of consistent changes in the system of procedures, it is enough to make changes to the system of concepts (model of the system under consideration) and the system of axioms (tactics of forces and capabilities of weapons), then the system automatically changes the calculation procedures and control procedures. In this case, the time required to adapt the control system to changing conditions is significantly reduced. The management crisis, which was discussed at the beginning, can be overcome by quickly restructuring the management in changing conditions.

The construction of the procedural rules in the automatic (automated) mode can be carried out on the basis of a certain set of initial (basic) procedural blocks (constructs) [12]. To date, a team of researchers led by Academician S.P. Nikanorov developed a set of such constructs that are characteristic of models (concepts) of systems of various types [13]. For the designed system of organizational management of forces, these are such types of systems as: open static system (for planning mode) and targeted stream system (for operational management mode). In [12], models of systems and the corresponding methods for synthesizing procedural procedures, based on sets of constructs characteristic of these system models, were proposed. The method of synthesis of consistent systems of procedures, based on the system of axioms and the system of concepts (system model), is based on the approach of tensor analysis of networks [10].

Consequently, the further development of the theoretical results that were obtained in the framework of the creation of the mentioned modeling complexes should be:

- isolating fragments from the system of created computational procedures that can be interpreted as concretization of constructs from lists characteristic of the systems under consideration;
- the addition of many interpreted procedural fragments, procedures that interpret the remaining unaffected constructs;
- the addition of many axioms with information on the tactics of the use of forces;

- development of procedures for the synthesis of computing systems for the planning of the use of forces and their operational management as a concretization of the results of the constructive design of procedural regulations;
- expanding the results obtained to the entire class of systems of organizational management of forces, including processes for managing development, security, and training.

To solve these scientific problems, it is advisable to use the following research scheme (Fig. 6).

Indicated in the figure:

1 – Interpretation of a system model in relation to certain classes of models from the model library;

2 – The choice of sets of constructs used to describe the functioning and construction of procedural regulations of systems of a particular class;

3 – Interpretation of the construct system and operational calculation procedures. Isolation of basic elements of algorithms as concretized constructs;

4 – The inclusion of the basic provisions of tactics in the system of axioms.

At the first stage, it is necessary to identify the classes of system models that are used in the design. For classified models, identify them with a specific subject area. Concretize concepts, their interconnections, define construct systems with the help of which the subject area and functioning processes in the organizational system of the class in question can be described.

Next, you should interpret the established list of constructs on the system of computational procedures, isolating from it the basic computational algorithms corresponding to certain constructs.

Also, from the initial list of calculation procedures, axiomatic provisions on the tactics of the use of forces should be distinguished, including them in the system of axioms.

For the basic list of calculation algorithms, using tensor analysis methods, it is necessary to develop a methodology for synthesizing the procedural rules of the organizational management system on the basis of accepted management axioms (initial data on calculating the capabilities of weapons and special equipment, basic provisions on the tactics of using forces).

The end result of this kind of research should be the theory of designing organizational management systems with a customizable system of functioning procedures depending on changes in the concept of the use of forces and management of the processes of their application.

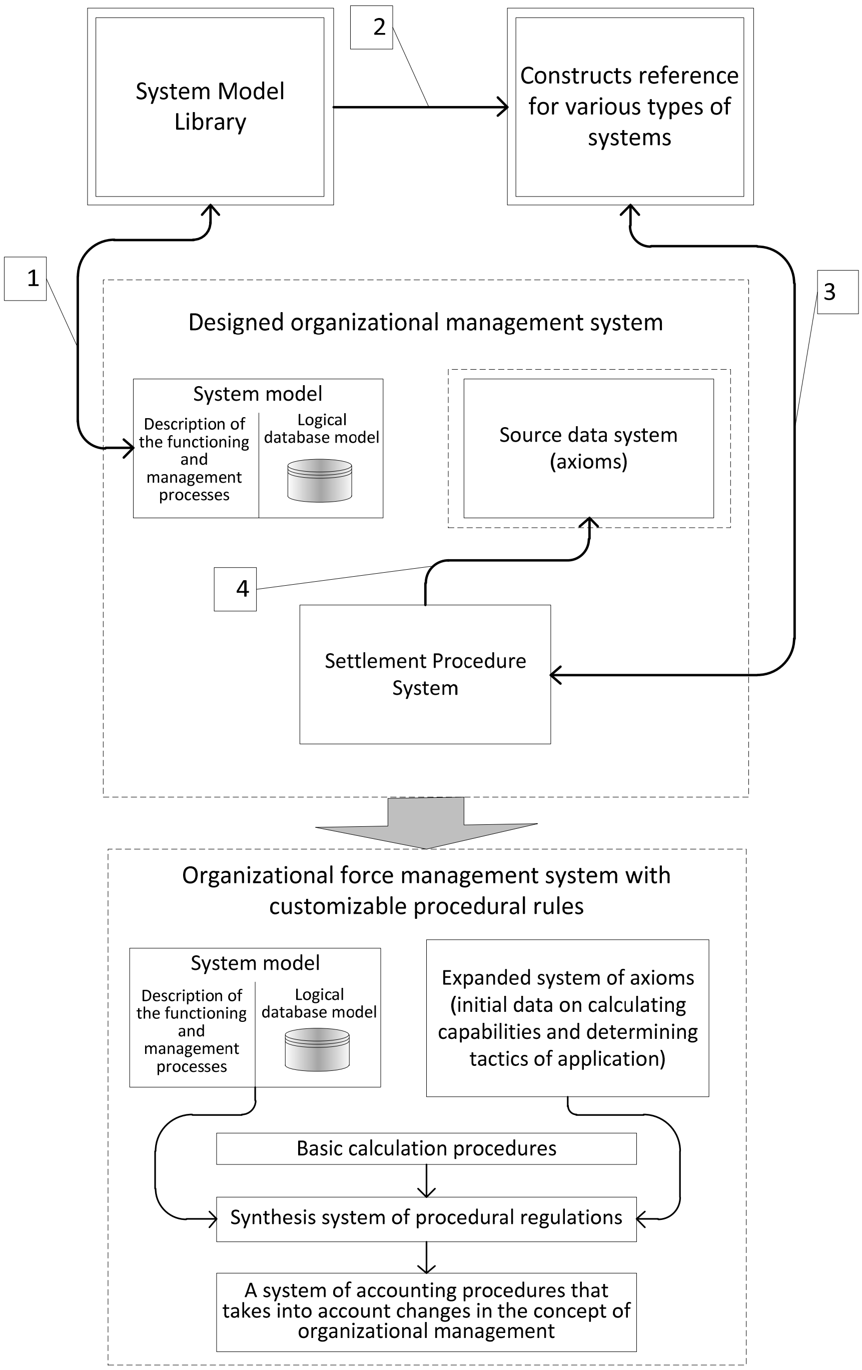

Fig. 6. Directions for further research on creating the theory of designing systems of organizational management of forces.

4 Conclusion

Thus, the current management crisis is due mainly to insufficiently fast adaptation to the rapidly changing conditions of existing institutional systems of organizational management, as well as the mismatch of the mathematical models and decision-making methods used in the actual complexity of real controlled processes.

In IPRI, using the design environment of modeling complexes of automated control systems, work is underway to create effective organizational management systems for forces for foreign customers. To date, significant results have been achieved that allow us to talk about automation of the aviation complex and naval forces. The developed automated organizational management systems are adequate to the existing concept of the use of forces and means and significantly increase the efficiency of control bodies through the use of distributed decision-making methods based on a large ontological network in the modes of application planning and operational management of the use of forces.

Nevertheless, the ever-growing capabilities of modern means of warfare, the emergence of new types of weapons, including those based on new physical principles, in a fairly short time perspective, lead to a revision of the concept of the use of forces and, therefore, the need to improve previously designed organizational management systems for this area.

In this article, the authors formulate ways to further develop the theory of designing organizational systems based on the use of modeling systems in order to accelerate the adaptation processes of software of automated systems in the context of a rapid change in the concepts and paradigms of the use of forces.

The methodological basis for the created design theory should be the theory of conceptual design of organizational management systems, including the methods of tensor analysis of networks.

The main content of prospective studies should be the tasks of interpretation and concretization of generalized models and constructs of systems of a certain class for the developed description of the subject area and the created system of calculation problems. Also, for an educated, concise list of constructs, a description of the process, and axioms of the use of forces, a method should be developed for synthesizing the procedural rules of the system using the theory of tensor analysis of networks.

The successful solution of the above problems in relation to the implemented projects of automated control of forces will allow us to create a theory of designing organizational management systems with the provision of adaptation of procedural regulations to changing management concepts.

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