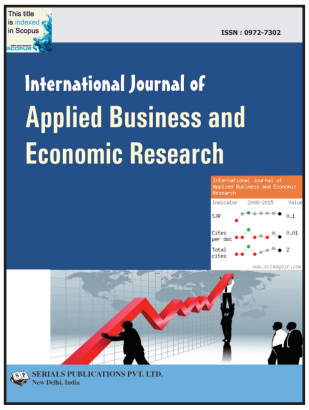

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Approaches to the Study of Complex Systems using Modeling Method and the Method of Construction of the Road Map

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ABSTRACT

Annotation: The subject of the article is complex systems research and modeling which is difficult due to their large dimensions and a set of states. The task was set by the scientific substantiation and description of how the application of methods of scientific knowledge, which formed the basis of the sample and the correction of the control parameters of a complex system, and provide the ability to monitor the behavior of a complex system trajectory. As a complex system was adopted by the information-analytical system of support of public control in the sphere of public procurement being developed at the moment. As the forming of an environment considered contractual system of the Russian Federation for state and municipal needs. Development and testing of this system is applied the purpose of scientific research conducted in the framework of the state order and financed by the Ministry of Education and Science of the Russian Federation. Given the variability of poly-scientific approaches to the solution of a scientific problem, interest and the process of the sample used methods. The working instruments were chosen method of construction of the road map and the simulation method. This article describes how to use these methods; it reflects the sequence of actions and decisions to optimize the research path.

Keywords: Complex system, a method for constructing a road map, a method of modeling, information-analytical system, social control in procurement.

1. INTRODUCTION

This article contains a report on the process and the results of practical application of scientific problem solving. The specific research objective was to determine to justify the use of scientific methods and

describe the procedures for their use in research projects. Name of research project - the development of information and analytical support (hereafter - IAS system) introducing methods of social control in procurement for state and municipal needs. Classifying carried out research should indicate the following. According to sources of research funding is classified as a budget funded by the Ministry of Education and Science of the Russian Federation. By purpose the study is classified as applied, is aimed primarily at the application of new knowledge to achieve practical goals and specific objectives. As for the practical results is necessary to introduce the practice of specific application of research results, the study conducted by purpose related to scientific research. For the duration of ongoing research is classified as a conditional term, the schedule of the operations is formed by three calendar years. On set of approaches and methods of scientific knowledge conducted research classified as experimental and analytical.

In general, the scientific (research and development) activity - an activity aimed at the acquisition and application of new knowledge. With regard to the topic of the research project - an activity aimed at the acquisition and application of new knowledge in the field of information and analytical support in the implementation of integrated management solutions. In the formation of the scientific objectives were taken into account external and internal limits of scientific research. Internal limitation is the need for testing of intermediate and final results of the development of the IAS on independent outdoor areas. As such, they have been selected: the site of the Russian public organization "Homeland Security" and the website of the Russian Association of public control on the basis of the Public Chamber of the Russian Federation. External restrictions are valid contract system in the sphere of state and municipal needs and ensure its activities are national information systems. These include: Integrated Information System (hereinafter - EIS) and the State integrated information system of public finance management "Electronic Budget" (hereinafter - IS "Electronic Budget"). These systems are designed for effective procurement management products and promote the development of a unified system of budget management [1, p. 12].

How to solve the scientific problem was divided into several stages. The first stage consisted in the definition of scientific methods which are suitable for use in the implementation of a research project. The second step should justify the choice of scientific methods conducive to the achievement of the anticipated results on the basis of research projects. The third stage describes how the use of selected scientific methods in the implementation of a research project on the development of the IAS.

It should be noted that the developed system IAS relates to the class of intelligent agents, it provides a distributed organization of data and perform the functions associated with the use of application programs that are located in different subscriber systems on the Internet [2]. The developed system of IAS also has promise for use as business intelligence (BI-systems - Business Intelligence [3]). It provides data processing in accordance with the user's request, provides a convenient interface for a comprehensive study and evaluation of the information received. The only restriction placed on the data sources. In contrast to classical BI-systems that use contextual and semiotic search, the system uploads the data from the IAS ftp-server xml-format documents.

In the first stage of the solution of scientific tasks carried out a range of actions aimed at a comprehensive study of objective conditions for the realization of a research project, the process of development of options for obtaining useful results and the implementation of the development of AIS. It was established that for the implementation of a research project in demand mainly empirical methods of scientific knowledge.

It was found that the level of empirical scientific knowledge optimally meets the objectives of a research project on the development of the IAS:

- the development of a model of information-analytical support of the implementation of the methods of social control in procurement for state and municipal needs;
- the introduction of the model of information and analytical support for the implementation of the methods of social control in procurement for state and municipal needs.

Empirical level of scientific knowledge leads to the following practical results in the following areas:

- to define a set of parameters and the order of the hierarchical structure of the model of information and analytical support for the implementation of the methods of social control in procurement for state and municipal needs;
- development of organizational and functional structure of the information field for an open interaction of the system of social control in procurement for state and municipal needs.

In the second stage solution of scientific problems was conducted rationale for the selection of scientific methods to help achieve the planned results following the results of research projects. Justification conducted to determine the extent of demand in the use of a particular method of scientific knowledge for the intermediate and final results of the research project. The method was considered reasonable if it matches the parameters of the optimal use of current conditions and future development of the scientific project, the parameters of the target destination, parameters of promising implementation of the results obtained during the study. As a result, we were selected by two methods: a method of constructing a road map and a simulation method. It is possible to carry out the following types of applied research:

- development of the dynamic structure of the processes of information and analytical support for the implementation of the methods of social control in procurement for state and municipal needs;
- development of a prototype program of information and analytical support of the implementation of the methods of social control in procurement for state and municipal needs.

In the third phase solution of scientific problems was presented a description about the selected application of scientific methods in the implementation of a research project on the development of the IAS. The method of constructing a road map was used in the planning and implementation of operational control over the process of implementation of a research project with consistent adjustment of actions of participants of the project. This method is also helpful in the distribution of all kinds of resources planned in the design and optimization in the process of implementation of the scientific project. The simulation method was used in the construction of a working copy of the program of IAS, in which were reproduced properties of the object. Formed design was a basic reference point for developers in the process of testing the results of the study, which ensured the preservation of the characteristics of the planned program of the IAS, and the initial vector in its set-up and improvement. Using these methods combined to produce performance:

- for testing of information and analytical support for the implementation of the methods of social control in procurement for state and municipal needs;

- the monitoring of the program of information and analytical support for the implementation of the methods of social control in procurement for state and municipal needs;
- at an estimation effectiveness of the program of information and analytical support for the implementation of the methods of social control in procurement for state and municipal needs.

2. MATERIALS AND METHODS

In the theory of complex systems are characterized by the following features:

- complexity and stochastic relations between the elements;
- ambiguity algorithms behavior under various conditions;
- a large number of parameters and variables;
- incompleteness and indeterminacy of the initial information;
- diversity and the probabilistic nature of the external environment.

The developed system is characterized by all the signs of IAS complex systems. Firstly, the IAS system is hierarchical because it involves interdependent subsystems that integrate information systems of the pilot sites and EIS, IS "Electronic Budget". IAS System Architecture and consists of components of the system and the hierarchical relationship of these components [4, p. 8]. There is a certain freedom in defining and selecting the elementary components of this complex system. This process depends on the composition and content of the tasks which should solve the system in the provision of services to users in the processing of statistical and analytical information on state and municipal procurement. The dynamics of the interaction between the components is weaker than the dynamics of interaction within the components, it can not only separate the functions between parts of a complex system, but also to study, modify each part. When working with this complex system, the principle of proportionality types of subsystems, the unity of structure and organization. This contributed to the process of forming a complex system - from the development of simple systems and the design of their interaction with the health condition of each simple system. The evolution of this approach involves the future development of this complex system, including converting it into elemental composition of an object in a more complex system. However, it is obvious that the development in this direction is possible only on the results of studying the behavior of complex systems formed. When designing the system IAS, described as a complex system, there were many challenges that required assessment of the functioning laws of the subsystems, on the order of their interaction, and further - to study their behavior. To solve these problems have been taken into account the following conditions:

- the need to synthesize the optimal structure of a complex system with the specified characteristics;
- the possibility of different options for structuring the system to ensure the required characteristics;
- the apparent impossibility of structural and parametric synthesis subsystems without modeling method;
- limitations of the experimental study of sub-systems;
- the need to provide the functioning of objects of research.

As a result, optimal synthesis of complex systems has been achieved through the application of the method of construction of the road map. This ensured the effectiveness of the design process of a complex system in the process of synthesizing its structure and analysis of options for the structure, which is an indicator of the effectiveness of the designed system. For complex system testing and study of the dynamics of its operation method it was used semi-natural simulation. This was facilitated by the use of the actual devices of IAS to simulate operation of all system devices and improve IAS program for unloading data from state information systems. The most difficult moment, considering the characteristics of complex systems, the research process has been designing behaviors subsystems. At this stage, this problem is not completely solved, because the IAS system is still not working at the pilot sites. In the current environment, researchers are only the results of modeling the behavior of complex systems, given that there is an adaptation of subsystems for the variance of user requests to the IAS system.

In the process of designing a model system behavior were taken into account the requirements of the IAS approach of successive changes in the development of complex information systems [5], which involves continuous analysis of work performed, followed by engineering and the physical embodiment of design results. The result of each iteration improved the quality of development by adjusting the model of IAS and its implementation. The disadvantage of the approach of the absence of quantitative values to assess the degree of approximation to the results of the iteration goal has been resolved by establishing a finite number of parameters, and user requests to the IAS system. It is allowed to reach the final iteration, the result of which was the lack of errors in testing behaviors of IAS.

The following is a description of the method and procedure for the construction of the road map and the modeling method in a third stage of the solution of scientific problems by the use of selected scientific methods in the process of implementing the scientific development project of IAS.

The method of constructing the road map is a way to develop a comprehensive action plan to achieve these goals and present scenario of the research object. The method is used for a wide range of strategic objectives in different areas of management by visualizing the results of planning, implementation and monitoring of project-oriented activities. Building a road map allows present and discuss in detail the stages of the project implementation schedule, critical tasks and order of their execution, as well as the main results in accordance with the program-target method. The main advantage of this method lies in the clarity of vision, strategy of development of the object by applying temporary grid main steps of the process of planning, implementing and monitoring a single project.

As part of the project is not executed task was to determine the profitability of the project, or select an alternative product strategy, and cost estimates of resources and economic efficiency of the project, the main purpose of the roadmap was to ensure information support of decision-making on planning and development of the research object. In this case, the road map is not designed as a plan-forecast of the facility in the long term; its development was an expert opinion on the implementation of a research project to improve the system of information and analytical support for the implementation of the methods of social control in procurement. The roadmap contains step by step instructions for the implementation of administrative decisions made by experts. Potential roadmap project is to provide the most optimal way of taking into account the threats and opportunities of spent resources and evaluating results.

Roadmap for the implementation of scientific development project of IAS is an interactive tool that will amend and supplement the view of real, terminate or potential factors whose impact was reflected by

mapping. This specificity and effectiveness of the method defined as a road map not only performs the function of "look into the future" on the future of the state and content of the object of study, but also the function of providing management decision-making at the stages of operational planning, monitoring and evaluation of the project. The degree of maturity of the main modules of the road map determined by the specifics of the project and the tasks that have set themselves the researchers, while was considered the possibility of changes in the layout of the interactive maps, with the justification and regulation introduced adjustments. Summarizing the appropriate method of constructing the road map targets research projects on the development of the IAS should summarize. This method will produce the following effects:

- simulation of realistic goals and project formulation in accordance with them the most effective ways of achieving them;
- integration of data on the most important aspects of the content of internal and external environment and their trends;
- identification of the interim results and further adjustment of the realization of the project;
- consideration of strategic and operational objectives of the project taking into account all its aspects (resources, technology, legal and information support and others);
- consideration of future risks of the project;
- consideration of the time slots and capacity of the project Source of project on each of the intervals;
- creating a visual display of the decisions on the project;
- updating and expansion of the sub-project, both vertically (adding new stages, new directions), and horizontally (detailing activities target indicators).

The simulation method is a method of scientific knowledge, which involves the creation and study of the behavior (reaction) model. Application of this method allows obtaining new knowledge, a holistic view of the object of research, particularly its functioning. The main features of the method are: visibility, abstract. Application of the simulation is necessary for visual expression of a scientific hypothesis, and to confirm the possibility or impossibility of its functioning in reality. The modeling carried out a comprehensive study of the model object to create - working copy that reproduces the properties of the object. Depending on the purpose of the simulation, the researcher determined, you can create different models to separate the object of study. Models are classified on the basis of domain reproducible properties on the subject models and information models. Subject models reproduce the functional properties of objects in material form, showing the physical capabilities of the model. To do this in the simulation method using a scientific experiment, the method of complex tests or the manufacturing method of the experiment. Information models represent objects (processes) in the figurative or symbolic form. Shaped information model is, for example, drawing, layout. An example of a symbolic form of information model is, for example, the program in the programming language formula.

As part of the study using the method of modeling the current study did not happen, and the designed system to optimize the functioning of the mechanism. In our case, the modeling subject to all the processes of decision-making on the basis of the information received. For the purpose of ongoing research used

simulation information model in symbolic form. It was fully reproduced algorithm were the object of study in time. Imitations have undergone all the elementary phenomena constituting the process of using the program information and analytical support of social control in procurement. Thus it was preserved the logical structure, the sequence of processes, especially the interaction of the structural elements. All this has allowed to accumulate data on all the possible states of the process at certain times and to form a report on the characteristics of the operation of the facility.

The use of simulation as part of the research project was justified by the need to solve a composite task - the development of an information resource, providing the implementation methods of social control in procurement. It is known that the simulation models allow taking into account the non-linear characteristics of the elements and processes of the object of study, considering and handling the random effects of factors internal and external environment that is almost insurmountable obstacle in conducting analytical studies. In this regard, it is apparent that the use of simulation for the purpose of ongoing research is the most effective method of research among the scientific methods that form the understanding of the characteristics and patterns of behavior of the object.

The structure of data organization model was developed by the network, that is a model in which objects are arranged in levels, but the processes are not in a linear relationship. By the time factor is developing a model refers to a type of dynamic models, as anticipated study of the processes change and develop state of the object of the study. According to factor utility model developed model refers to the type of game models as it creates a model designed to study the behavior of the object under various conditions, a kind of rehearsal for.

As a general approach to modeling as part of the study used an approach called "black box", which is applicable in the case where the internal mechanism of the functioning of the model is complex, unknown or not important within the objectives of the study. For research conducted internal mechanism of functioning of models and complex known as subject to change and develop under the influence of external factors. Using the approach "black box" allows us to study the behavior of the system and its response to various external influences when abstraction from its internal structure. Thus, the basic principle of the approach "black box", is to study the reactions of the system to set the input and transformation in accordance with the external signals internal maintenance system used to develop and test a model of an information resource as part of the study. To do this, in the studied systems were provided "input" to enter information about the external factors affecting the system, and data validation model, and "Exit" to display the results of the work on the transformation of the inner content of the system.

3. RESULTS AND DISCUSSION

The proposals developed by the method of construction of the road map became the basis for the implementation of the principles of program-target method of management when dealing with a system of information and analytical support for the implementation of the methods of social control in procurement. In developing the road map as part of the study were the following assumptions:

- functional blocks of map is a the main directions of the process of creating and implementing a set of actions for development and testing of information-analytical resource, providing support for social control in procurement;

- Road Map is not an instrument of forecasting, it was designed to integrate the requirements to ensure the future results of the project for development and testing of information-analytical resource, providing support for social control in procurement;
- the Roadmap is a document that reflects the standard plan for the development of application tools to enable the introduction of methods of social control in procurement.

The Roadmap has become an instrument that combined action on the development, testing and monitoring of the project results in a single set of actions of participants of the project, in particular, the developer of the IAS and the authorized representatives of the pilot sites. The interaction between the parties took place on the stage of development of the road map and at the stage of actual implementation of a research project developed on the basis of the road map. Work on the road map has been conditionally divided into a step of forming the elemental composition and the stage of the road map process control, taking into account their structure and mechanism. Adoption of a model scheme in the drafting of the roadmap can be used when applying the method of developing a road map for other research projects, which provides for the development and testing of the final product at a constant interaction with the pilot sites. Interrelationship between subprocesses in all stages illustrated in Figure 34.1.

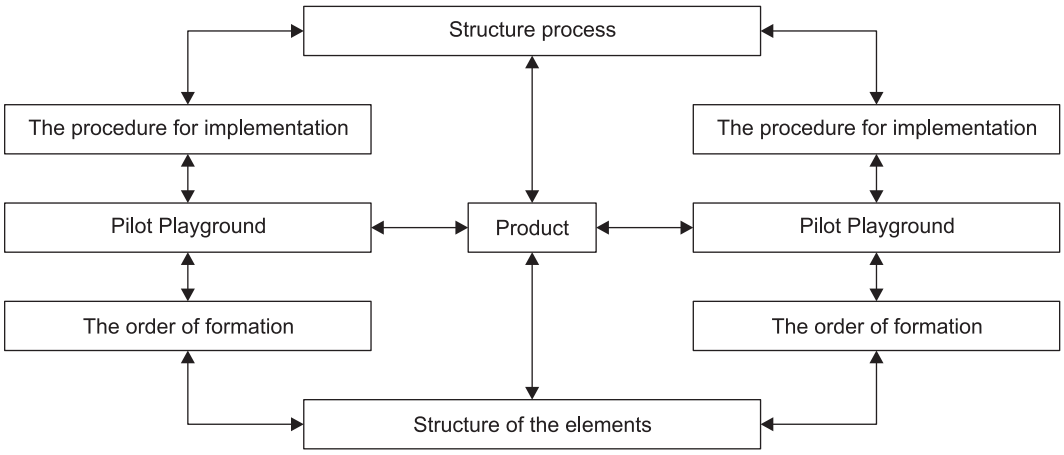

Figure 34.1: Typical project roadmap

Typical project roadmap based on assumptions included the relationship of the main structural elements and processes necessary for the development and testing of the final product - the road map. Typical was characterized by constant contact between the developer of the IAS and the representatives of the pilot sites for the coordination of actions for the creation and implementation of the road map.

The procedure adopted by the use of a template when drafting the roadmap presented research project is shown in Appendix 1. The scheme takes into account both the structure of the elements necessary to develop a roadmap and structure of the processes by which the management of the project as well as a set of activities that make up the formation and implementation of the order of the final product - the road map. The scheme also illustrates the process of negotiation (approval) a set of measures at each stage of the project implementation roadmap with pilot sites.

Coordination of the parameters the Road Map and the implementation of measures to manage the process of implementing the roadmap occurs through direct interaction with the pilot site because it is

they planned testing of the IAS, which provides support for social control in procurement. Therefore, increasing the risk of the establishment of IAS due to the need for continued coordination of actions with the developer of the pilot areas is justified in terms of creating a resource that is in their parameters fully meet the interests and capabilities of each pilot site.

The process of working on the creation of IAS occurred in parallel with the two pilot sites. Therefore, despite the identity of the source to the functional requirements of the system, developers were willing to accommodate the interests and capabilities of each pilot site. Also with respect to each pilot sites were considered typical technical limitations. The general scheme of the process of creating and implementing a roadmap taking into account the order of interaction with the pilot sites is illustrated in Appendix 2.

Presented in Appendix 2 six stages in the preparation of specifications for creation of IAS (in accordance with GOST 34.602-89 "Information technology. Set of standards for automated systems. The technical project on creation of the automated systems") were presented in the form of time intervals, the duration of which was no more than a calendar year (under the terms of the Terms of Reference of a research project). The results of the preparation and implementation of the roadmap for the project have been decorated in the form of documents in accordance with the stages of the passage of the map: the terms of reference for the project (the road map); Project Roadmap (present visa agreement and approval); a quarterly report on the project (present visa agreement and approval of the intermediate results of the implementation of the Road Map); Opinion on the results of the project; a report on the implementation of the project with the recommendations of the project (present visa agreement and approval of the final results of the implementation of the road map).

Interim and final reports on the results of the implementation of the Road Map containing reporting data on the achieved value targets under the activities envisaged by the project implementation of the roadmap. Reporting was formed along two lines - reports on achieved values of indicators and report on the implementation of activities. All provided by the project roadmap actions have been formulated in a number of tasks that characterized the readiness and effectiveness of the project for development and testing of the IAS, which provides support for social control in procurement. Forms of Presentation of the project are presented in Tables 34.1 and 34.2.

Table 34.1
Information on the target values achieved for _____ (specify the quarter or year).

No.	*Name of the task, the target indicators*	*Unit of measurement*	*The planned value of the index*	*The actual value of the index*	*Deviation from the fact that the plan (+/- ; %)*	*Reasons for rejection*	*Measures to adjust the value*
1.	The challenge 1						
1.1.							

Table 34.2
Report on the implementation of activities

No.	*Event*	*Unit of measurement*	*Options **	*Implementation period*	*The degree of implementation (%)*
1.	The challenge 1				
1.1.					

Options * - must comply with targets

The process of creating a model in the framework of the solution of scientific problems assumes the passage of several stages. The first phase was carried out a comprehensive study of the experience and the formulation in accordance with the objectives set by the researcher simulation hypothesis, laid the basis for future models. However, we determined the parameters of technical specifications for designing the model provided by studying similar and comparable practices. The first stage consisted in the presentation of information in a compact form of objects indispensable to the development of the model. The model thus was purely descriptive, helping researchers to understand the tasks and identify the resources necessary to implement them in the next stages.

In a second step the researchers accounted for a research program in view of the approaches to modeling. As part of the program prepared by researchers were identified organizational aspects, to ensure the practical activities of the research team. In the context of the construction of the model and predict its behavior under various conditions, researchers have made the necessary adjustments, changing the organization of work with the model on the basis of variations in the results. While working on the creation of the model is also carried out adjustment (specification) of the original hypothesis that underlies the model. In the third stage the researchers formed a final version of the model. By developing the second stage of the various options reconstructed model, the third stage of the researchers on the basis of options formed the final sample models (project models or models of individual processes). Thus, the choice was made on the totality of the optimal variant accepted criteria and limitations of the set of admissible. The third stage is also testing the model possible situations to make informed decisions on the management of the object of study with the help of simulation.

The sequence of these stages of model development within the scientific solution of the problem indicates the selection of a systematic approach to the study of the model. A systematic approach involves the formation of a holistic view of the object under study, taking into account the essential elements of the object, the links between them and the external relations with other objects of the environment.

Applying a systematic approach has identified the need for structuring systems (structural approach), that means determining the set of model elements, relations between model elements and objects of the external environment, reflecting their interaction. A more complex version of the study was the possible use of the functional approach to the study of the structure of the system and its properties, as this approach is considered algorithms the system behavior. However, at the first stage of development model for solving the scientific problem it was found that the use of the functional approach to the modeling of the IAS, is impossible, since the object of the simulation is a design model, and does not exist, and to identify the behavior of algorithms will be possible only at the stage of implementation of an information resource.

It was therefore decided to limit the structural approach to design, model and study its properties. An exemplary algorithm for a systematic approach in structuring model of IAS is presented in Figure 34.2.

In drawing up the algorithm we used the following designations structural modeling elements:

- goal-setting (G);
- formulation of hypotheses, simulation ($H_1 - H_n$);
- consideration of the initial data - signals from environmental objects (ID);
- design a model - for each hypothesis (D);

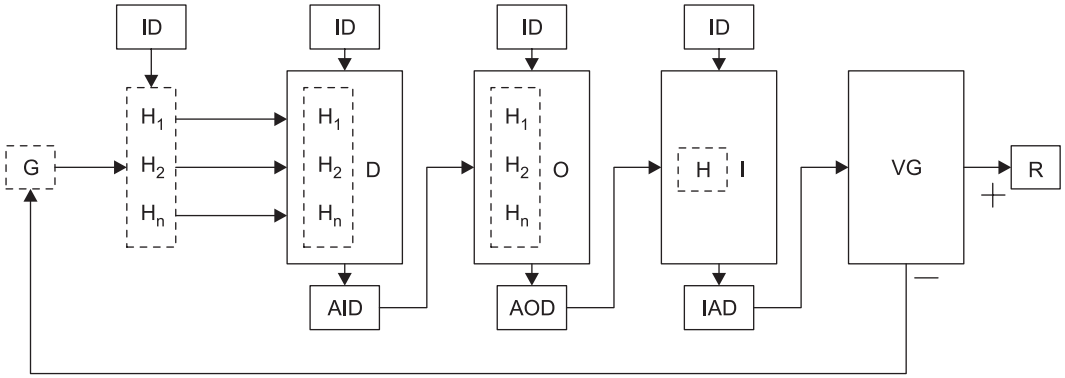

Figure 34.2: The algorithm for structuring models

- accounting data model design (AID);
- operation of the model - for each hypothesis (O);
- accounting data exploitation models - selection hypothesis (AOD);
- implementation of the model selected hypothesis (I);
- the introduction of accounting data (IAD);
- verification of compliance with the results of the implementation of this goal (VG);
- the results of the simulation (R).

This algorithm allows to take into account the peculiarities of the simulation of the research. In the process of simulation modeling subject to the elementary steps that constitute the alleged process of functioning of object modeling in the real world, in a certain time period and at a ratio of the interval and duration of operations within the process. Thus, the passage of all stages of the simulation based on the algorithm of structuring models were produced reasonable results necessary for solving the analysis and management of the real object - IAS system, providing support for social control in procurement.
The specifics of the object of research also led to the rejection of the application of analytical modeling techniques. Analytical methods are generally aimed at an understanding of the characteristics of the system and the parameters of its operation. However, their use is possible in simulation systems, for which there is a complete mathematical description of that missing respect to the projected model.

4. FINDINGS

Representation of the study and application of scientific knowledge (method of construction of the road map and the modeling method) allowed uniquely and positively identify the effect of management during the design and development of a complex system. The effect is to optimize the behavior of the trajectory of a complex system in all states when the predicted future operation of the system based on the results of its development.

The ability to control the development and testing in the future of a complex system, which is the IAS system, was provided by a combination of the method of construction of the road map and the method of modeling. All this has allowed identifying obvious and specific responses that occur when users query the

software system IAS in the implementation of the function of public procurement control and synchronize software of IAS with government information systems.

In applying the constructed model was a significant number of units in the structure of the IAS with nonlinear feedback. As a feedback circuits to a situation in the system for the decision. The result was the identification of possible deviations in the trajectory behavior of the system, corrected the errors that occurred in the process of working with the constructed roadmap. The application of the methods of scientific knowledge helped to identify the properties of the IAS.

It is particularly important that this result was obtained and confirmed in each feedback loop, where the researcher has the opportunity to fix the direction and limit changes in the behavior of the system, make a decision and then get a new flow of information. The new information flow always lies at the heart of the new solution. This property of complex systems has become both a point, complicating the process of the development of the IAS, and the time to open new horizons of research that should be used by researchers in the development of a more complex system for which the system is an integral part of IAS.

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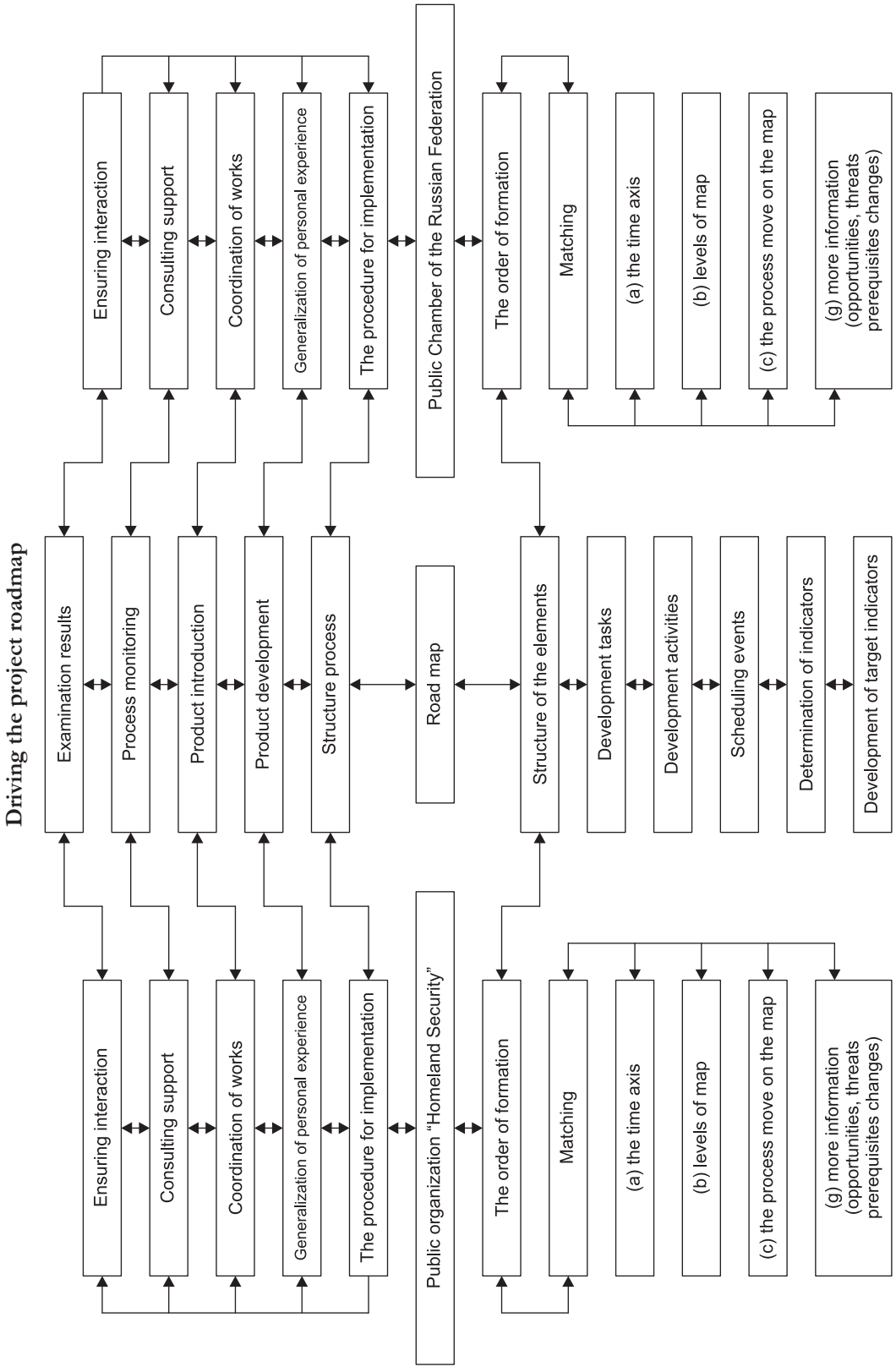
Appendix 1
Driving the project roadmap



Appendix 2

Driving the establishment and implementation of the road map