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METHODOLOGY FOR DESIGNING ANALYTICAL INFORMATION SYSTEMS FOR ADMINISTRATIVE MANAGEMENT

Introduction. In the field of administrative management, the intensity of management activities and the amount of information that needs to be processed for decision-making are constantly growing. In these conditions, the use of new information technologies in the analytical information activities of administrative bodies and the construction of appropriate automated systems is of particular importance.

Problem Statement. There is an urgent need for a new approach to solving problems related to the development of analytical information activities and the automation of administrative activities of the authorities. Such an approach should be based on information, consider the modern idea of information as an intellectual product, i.e. knowledge, and as a resource of society, and ensure the complexity of solutions.

Purpose. The purpose of this research is to develop a methodology for designing analytical systems based on the integration of concepts, models, methods and information technologies, given the requirements for the complexity of solutions.

Materials and Methods. The methodology is based on concepts, models, methods, and information technologies, given the requirements for complexity, support for management decisions based on knowledge-oriented tools, their comprehensive information support, support for document processing, information and cybersecurity, as well as the integration of analytical information systems with interoperability.

Results. Based on the study, an example of methodology for building a typical information and analytical system of administrative bodies has been proposed. It can be used in the construction of automated systems in various governments, in particular regional government.

Conclusions. The theoretical foundation is the regulations for the processing of document flows in the administrative authorities, based on the requirements of the policy of enforcement. The practical significance of the obtained results is the creation of a scientific and methodological framework for building analytical information systems in various areas of administrative management.

Keywords: analytical information system, decisions made support, administrative management, ontology, and analytic hierarchy process.

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Our days are characterized by digital transformation in all spheres of country's and society's functioning, the interdependence of technologies and industries. The requirement to adapt to new challenges is one of the main features of administrative management, which was determined at the beginning of the new millennium in terms of forming the information society. These challenges concerned, in particular, the ability to effectively respond to the requests of the population and business structures, to the development of technologies, to any unexpected changes in order to anticipate managing them (Fig. 1).

Objectively, administrative authorities regularly come into conflict with contradictory interests of different actors, which create a changing, dynamic information environment that is constantly evolving [1]. These factors manifest themselves in the form of information flows that are becoming more intense and take on the mass character.

Speeding up the adaptation of the management sphere to these conditions is impossible unless new knowledge based on analytical models and processing relevant information is generated. Also, in such situations, when the scope of tasks is constantly growing, while time and resources for their implementation are very limited, administration should be guided by a regimented bureaucratic work based on established processing procedures, discipline, and standards.

It is vital for the field of management, where the intensity of management activities and the amount of information to be processed for decision-making are constantly increasing. In these conditions, the use of new information technologies in the analytical information activities (AIA) of administrative authorities (AA) and the construction of appropriate analytical information systems (AIS) is of particular importance. Such systems should ensure the efficiency of decisions and achieve a qualitatively new level of AIA. In many countries (the United States, Canada, South Korea, Germany, Estonia, and others) the formation of the infrastructure of information space of EU governments has been initiated.

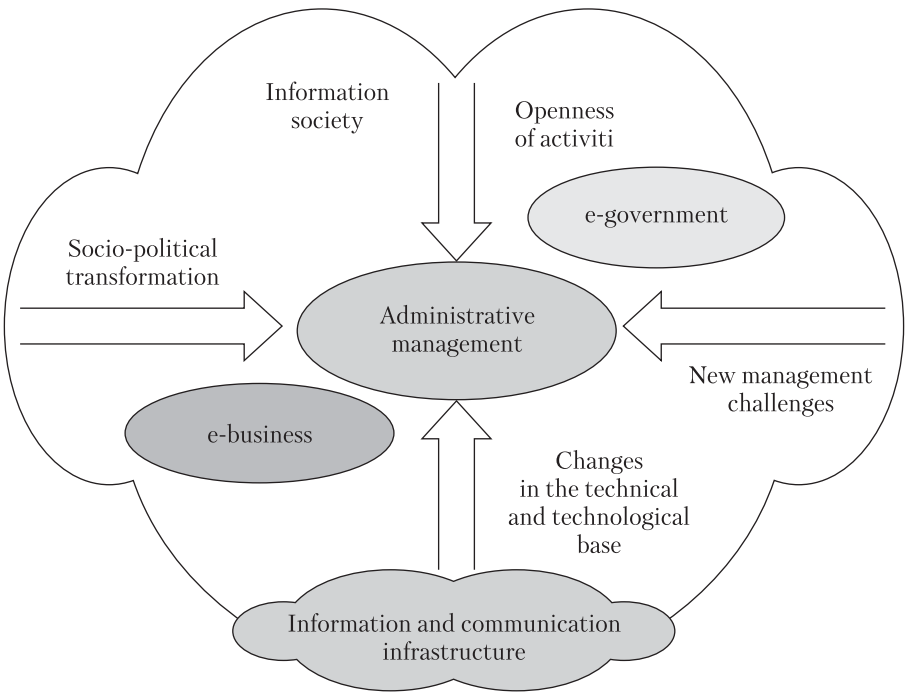


Fig. 1. Factors that influence administrative management in modern conditions

The object of study is the processes of information and analytical support of the administrative bodies.

For creating information systems in AA, different, sometimes contradictory approaches are used. Insufficient attention is paid to the factors of information support of the activity. There is almost no consistency in the design of decisions in different systems and the general tasks of informatization of the management sphere. It is primarily due to the lack of problem-oriented design methodology, imperfection of mathematical methods and programs for ensuring analytical activities and adapting to modern requirements.

The subject of this study is the principles, concepts, models, methods, and means of information technology to ensure the information and analytical activities of government in the modern information environment.

The lack of a holistic approach does not allow us to consider the process of forming systems and their developing them comprehensively from a systemic standpoint. It slows down the analytical processes in AA.

The purpose of this research is to increase the speed and quality of AIA processes on an information foundation, based on the modern idea of information as an intellectual product (knowledge) and to ensure the aggregate and integration of solutions.

Let the external environment be presented as a constantly changing information space. Thus, the information infrastructure I of the management sphere can be described as some metasystem consisting of sets $S \subseteq I$:

$$I = \{S_1, S_2, ..., S_i, ...\},\ i = \overline{1, \infty}, \qquad (1)$$

where S_i is the system of i-th AA (further to generalize, the index i is omitted).

The influence of the external environment on S is characterized by multidimensional random variable w:

$$w = (w_1, ..., w_m, ...), m = \overline{1, M}, \qquad (2)$$

where the dimension M and the functional content of the components of the variable w are largely individual to each AA.

Obviously, AA is a dynamic system because the output parameter at any time does not depend solely on the current value of the input information flow and the state from which the evolution of the system begins. In general, the structure of the system of administrative management as complex dynamic system $S(t)$ can be described by the cortege:

$$S(t) = \langle E(t), R(t), Z(E(t)), F(E(t)) \rangle, \qquad (3)$$

where $E(t)$ is the set of elements that make up the system; $R(t)$ is the set of relations between the elements; $Z(E(t))$ is the set of states of the elements; $F(E(t))$ is the set of functions performed by the system.

Among many functions of AA, first of all, there are analytical activities related to setting goals, analyzing the situation, finding ways to solve problems. They aim at developing a draft management decision and preparing for its adoption, that is, they are the most creative. Another part of the functions is operator work aiming at performing stereotyped operations necessary for information support of the analytical process. Usually, this work includes operations with documentation, information processing, and formal logical calculations. These two activities together constitute the part of management work that relates to information analytics and is usually provided by information technology.

Thus, we can conclude that a significant scientific problem in creating a methodology for building information systems, implementing digital technologies in existing management processes and business models is quite complex. The purpose of creating a methodology for constructing AIS is to find a solution that overcomes the problem of complexity and to give a tool for the synthesis and design of systems in the form of a single set of scientific and methodological provisions. In this regard, the process of system modeling of the problem-oriented

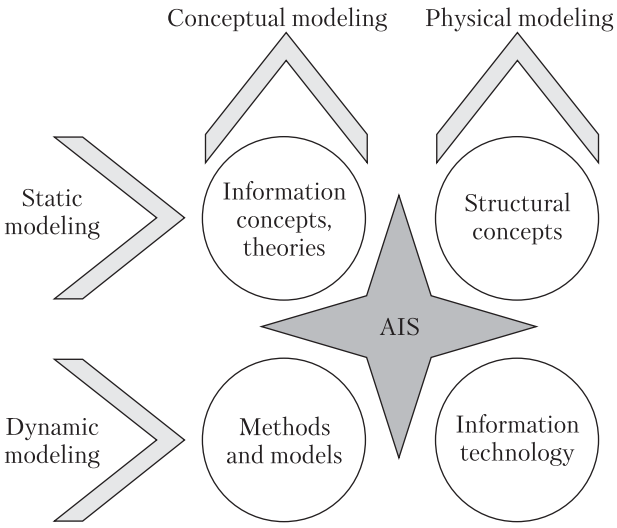


Fig. 2. The system modeling process of AIS

methodology for constructing AIS can be represented as it is shown in Fig. 2.

Disabling the problem of complexity is of practical importance for the breadth of the use of scientific results. All administrative bodies can use methods for solving problems of synthesis and design of AIS in the construction of various control systems. Also the solution to this problem has considerable political and social significance.

Thus, the systems analysis of AIS design problems for the field of administrative management should take into account the following factors:

(i) directions of information space infrastructure of administrative management development;

(ii) factors that affect the AA in current conditions;

(iii) methods and technologies of AIA automation in AA related to management improvement.

It follows that the design of AIS should provide:

(a) complexity requirements;

(b) support for management decisions based on knowledge-oriented tools;

(c) comprehensive information support of AA;

(d) support of document operation processes;

(e) information and cybersecurity; and

(f) the integration of various AIS in compliance with interoperability requirements.

The experience of organizational management automation has counted several decades. It is associated primarily with computer science pioneers Viktor Glushkov, Paul Gray, Edward Feigenbaum, and others, who proposed ideas and developed the scientific foundations of management information systems. Since then, the comprehensive coverage of various topics, including ERP development, web applications, notation, package development, and component-based design, illustrates how these technologies are integrated with social and economic factors to provide an in-depth look at information systems development. A similar contribution has been made in [2] based on the theory of social representation to build an analytical tool, through applying it to an illustrative example of cloud computing.

Simultaneously, there was gradually formed the opinion that it was impossible to ensure the building of an organization's AIS by modeling the entire system. As a result, one of the common critical flaws identified by the authors of many studies is that many developers think of parts of the system rather than of the whole. At the same time, it has been noted that based on the dominance of information evolution, the principles of organizational design and organizational change [3]. In addition, the derivative principles are the basis for creating analytical tools.

Recently, the use of analytical information systems has become critical for any organization. A wide range of modern methods and technologies for the development of such systems has been proposed. However, the existing methods are not integrated throughout the life cycle of AIS and do not correspond to their situational context [4]. It is primarily due to the complexity and dynamism of analytical activities as such.

The study [5] methodology that has the top-down approach has been used. Having identified problems with the subsystems, the authors develop the accounting information system of a surveyed company, which has different subsystems of accounting: payments, storage, properties, wages and salaries as one system. Based on the

studied methodology at the analysis stage, an appropriate model of the information system concept has been designed.

For creating an AIS, it is generally accepted to distinguish between the economic, the environmental, and the social dimensions, often interpreting the social problems as secondary. A good overview of this situation has been given in [6]. However, the social issues shall be among the priorities of administrative activities and need appropriate analytical support.

At the same time, it should be noted that a significant factor influencing the effectiveness of the AIS function in a government organization, is support for partnerships with business. Research [7] conceptually supports this idea, but shows that the empirical data are still scarce. To illustrate the macro-scale transformations between the public and the private sectors, two ethnographic examples of public IT projects have been discussed.

Creating an AIS is an expensive and time-consuming process that involves many stakeholders and leads to numerous engineering iterations. As a result, many researchers are looking for different approaches to improving methodologies for various conditions. Each approach has its limitation, specific interest, coverage, etc.

The need for well-structured systematics has been emphasized in [8]. The authors have tried to apply the taxonomy development method to classify the design methods and to identify the critical dimensions for overviewing the design methods. A clear understanding of the underlying definitions of methods, techniques, and tools is required as a conceptual foundation for creating the systems. Design method is regarded as a guideline for designers to test their design; design technique indicates a set of steps and activities during the design procedure; and design tool is specific software, template, device, etc. In this case, the design techniques are more detailed than the design methods and more general than the design tools.

The authors of systematic review of the literature presented in [9] have offered to reduce the bias of researchers. The purpose of the approach is to find and to review all research relevant to search definitions. This approach provides rigor that can help with a clear explanation of the selection criteria. As a research method, it effectively supports qualitative, quantitative, or hybrid methodology.

Research [10] has dealt with the consideration of conceptual bases and practical application of the methodology of inductive modeling of complex systems for the construction of appropriate technologies for system information analytical research of the innovative type.

The contribution to improving the methodologies, offering a balanced scorecard-based approach and reporting on the experience of developing and using it in the context of analyzing the demand for information has been made in [11]. The purpose of research [12] is to show an example of determining the components of AIS in the field of administrative management based on the qualitative content analysis.

The experience of developing such systems in production and business is important for the creation of AIS in the field of administrative management. Research [13] covers the development of the methods for constructing and implementing analytics as part of the technological management system in the face of a sharp increase in the information load.

The authors of research [14] have discussed how to present a formal way to use mathematical analytical methods in order to study the inconsistency of different concepts (information system, enterprise architecture, business processes) and the relationships between them. The analytical approach has been presented on the basis of the use of hypergraphs.

Digital transformation is associated primarily with the introduction of business intelligence and data mining. The process of designing and developing such systems as a new type of AIS has proven to be complicated and challenging. Methodological approaches to information systems engineering can potentially provide methods,

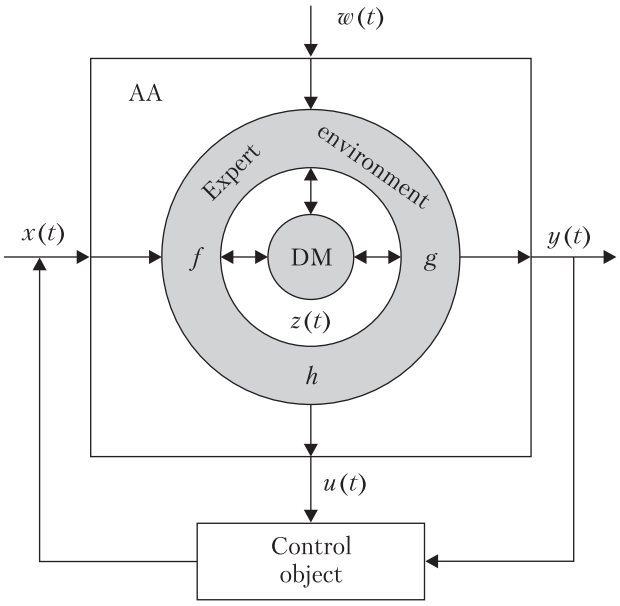


Fig. 3. The role of DM and experts in the analytical system

techniques, and tools for facilitating and supporting such processes [15].

The authors of research [16] have noted that the lack of awareness of the corporate data landscape affects the overall quality of data in organizations and the AIS methodology. The study aims at offering tools and methods to large organizations for enabling them to better understand the processes and organizational features, mainly through related data ontology.

Defining the fundamentals of the ontological architecture of the organization of information and knowledge is a modern development of AIS methodologies. For example, study [17] has analyzed a corporation in two dimensions: the descriptive and the normative ones. The explanatory part is based on formal ontologies of the highest level; the normative part is solved through the so-called social ontology. The relevance of analysis is based on the need for a better understanding of the organization, its structure and activities, and for ultimately creating a practical methodology for building AIS.

It should also be borne in mind that the next step in the digital transformation for many companies is expected to be digital ubiquity characterized by future technologies such as distributed ledgers, artificial intelligence or augmented reality, as well as decentralized apps and autonomous organizations. Thus, the challenge becomes to optimally deal with these opportunities and to deploy them efficiently in business scenarios [18].

As you know, control (management) in the cybernetic sense means the process of influence of a governing body on a controlled object for achieving certain goals. In this sense, each system S can be represented as (x, y, z, u, w, f, g, h), where x = $= x(t)$ is the input information flow, y = $y(t)$ is the output information flow (system response to the input effect), u = $u(t)$ is the control action, w = $= w(t)$ is the environmental influences, and z = $= z(t)$ is the internal state of the system.

These components are given as a finite aggregates of discrete time t functions (for example, x = $(x_1(t), ..., x_k(t))$, t = 1, 2, ...).

The functionals f, g, and h reflect the relationship between these components:

$$\left.\begin{aligned} z(t) &= f(z(t-1), x(t)) \\ y(t) &= g(z(t), x(t), w(t)) \end{aligned}\right\} \Rightarrow h: y(t) \to u(t). \quad (4)$$

The AA expert environment (Fig. 3) provides these functionalities.

An essential element of such systems is DM (decision maker). In general, the problem of decision-making from a systemic standpoint is formulated as follows. The control period [0, T] is fixed, the states of the object at the initial t_b=0 and the final t_e=T moments, $z_b(t)$ and $z_e(t)$. respectively, are known.

Unregulated change of state $(z_b \to z_e)$ = Δz is a problematic situation in respect of which a decision shall be made. DM is first faced with the problem of finding a field (strategy) of satisfactory actions, followed by the problem of choosing the best action, i.e., the solution in this field (strategy).

Let us distinguish a set of control action $u(t)$ from the flow $y(t)$. In systems such as AA, control influences $u(t)$ are decisions made at certain points in the system's trajectory. The decision-

making process in the general case can be structured into the following four key stages:

1) the selection of control actions from the output stream (the management problem):

$$u(t) \subset y(t);$$

2) the formation of a set of acceptable solutions (the analytics problem):

$$\{u_a\} \subset u(t);$$

3) the comparison and ranking of acceptable solutions (the evaluation problem):

$$\{\overrightarrow{u_a}\} \subseteq u(t);$$

4) the choice of effective (best) solution from an acceptable set of solutions (the optimization problem):

$$u^* \in \{\overrightarrow{u_a}\}.$$

Thus, h on the right side of (4) can be represented as a superposition of functionals h_1, h_2, h_3, h_4 at the corresponding stages:

$$h: y(t) \to u(t) \Rightarrow$$
$$\Rightarrow y(t) \xrightarrow{h_1} u(t) \xrightarrow{h_2} \{u_a\} \xrightarrow{h_3} \{\overrightarrow{u_a}\} \xrightarrow{h_4} u^*. \quad (5)$$

The set of acceptable solutions u_a is based on meaningful analytical analysis of the problem area of a particular task, which is a sub-area of the system's environment, limited by certain relations.

In the conventional formulation, optimization as a mathematical programming task involves an appropriate mathematical model. The AA belongs to the class of systems characterized by a dynamic change in the functioning of the structure, composition and quantitative values of parameters, target guidelines, etc. Therefore, it is impossible to realize the task of optimization in such a statement. Thus, such systems require unique problem-oriented decision-making methods.

The issues related to the quality of decisions made, although primarily addressed, are constantly evolving and have many unresolved problems, which deserves some research. However, the direct timeliness and efficiency of information processing of the flow of documents and, indirectly, the information validity, transparency of decisions are processed to a much lesser extent. Therefore, in the above model, we consider the quantitative parameters related to assessing the timeliness of the decision (i.e., the processing of a particular document). The definition of decision $u^* \in u_a$ also is associated with the concept of "the best" in the sense of "timely."

It should be noted that the decision-making environment in the AA in current conditions is described by joint processing of interconnected, diverse information, its integration and interaction with other different systems and subsystems. The search for knowledge and the statement of the problem, where views on the problem are determined, the criteria for choosing a solution, etc., are usually the first stages in the process of information and analytical activities. This stage aims at:

1) timely providing the expert and DM with the necessary information that shall be relevant in time, place, and volume;

2) ensuring the process of preparation of integrated data for the development of analytical data and solutions;

3) supporting the decision-making process from operational, tactical tasks to long-term strategic programs with complex, balanced goals and opportunities.

It is known that the construction of complex systems is impossible without stages of system analysis and object-oriented design. However, the main problem the search for suitable models remains unsolved. The basic principles of building models of complex systems are the principle abstraction, multimodality and hierarchical construction of models. The most common idea of complex system is considered static and dynamic representation.

According to the first principle, it is necessary to include in the model only those aspects of the designed system, which are directly related to the performance by the system of its purpose and functions. According to the second principle, the model is a quite complete complex system that

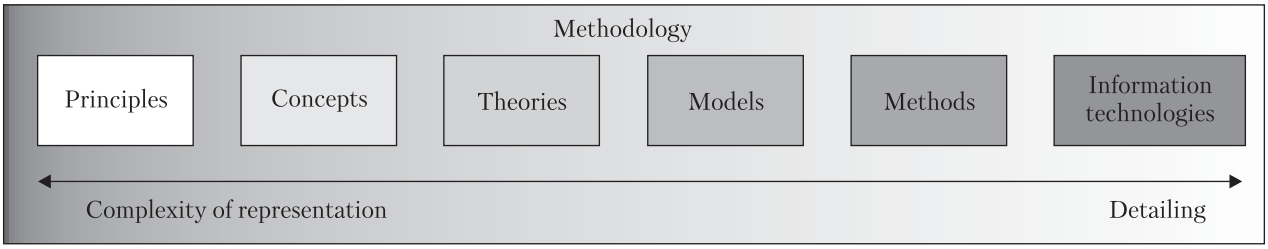


Fig. 4. The structure of the AIS methodology

can be represented only by some set of interconnected views, each adequately reflecting a specific aspect of behavior or system structure.

Finally, the process of model construction shall be considered at different levels of abstraction or detail within fixed representations, ranging from the most general representation (meta-representation) of the conceptual level to more partial and detailed pictures of the logical and physical levels. Accordingly, the structure of the AIS methodology can be represented in a way shown in Fig. 4.

Such tasks require the representation of the subject area by certain information models. Each such model reflects a set of knowledge that describes the properties of objects and processes to be analyzed. It is the choice of such an information model that significantly affects the effectiveness of solving the tasks.

Recently, the representation in the form of a particular set of ontologies has been considered the most adequate one among the existing approaches to the representation of information models in the environment of analytical systems [19, 20].

The following steps are to build a set of alternatives considering the current situation, i.e., to identify solutions. And the last stage already includes comparing the alternatives and choosing the best solution (or solutions).

The tasks of choosing alternatives among the problems of decision theory, which significantly often occur in practice are the most relevant. Such tasks are described by a set of alternatives, for each set of values of specific indicators (criteria). The solution to this problem is considered the alternative that has the best values of the criteria, which in the general case differ in importance. However, even in the simple matter of finding the best of several alternatives, one can often get illogical and contradictory answers of the experts. Overcoming such features of human consciousness shall be considered in the construction of AIS by providing support for comprehensive, structured information that adequately and clearly describes the problem area.

Usually, the problem of solving issues of decision support, i.e., determining the system of preferences for a particular action on a set of alternatives is numerous cases of multiple alternatives and multicriteria in their choice. In the general case, the difficulty of solving multicriteria problems is that the criteria compete. In most practical tasks, the search for a better solution by one criterion leads to the fact that the decision becomes less good on another criterion.

There are many methods for analyzing multicriteria situations. One of the recognized approaches in overcoming this problem is the analytic hierarchy process (AHP) [20]. As you know, this method refers to the interactive (expert) methods. The analysis of the decision-making problem in AHP begins with constructing a hierarchical structure that includes the goal, criteria (sub-criteria), and alternatives. The analysis of the situation of choosing the decision in AHP is similar to the procedures and methods of argumentation, which are used by human at an intuitive level. At the same time, any ontology contains information descriptions based on an ob-

ject-oriented formalization procedure reflecting the decision-maker's understanding of the problem. These features of the two methods under consideration are their common factors.

Information flows $x(t)$ and $y(t)$ in AA usually represent document flows that are the main information unit of processing. The AIS design methodology shall consider that the processing of document flows is associated with the requirements of timely execution of documents. The policy of executive obligation significantly affects the timeliness and efficiency of decision-making. Simultaneously, the implementation of the policy of executive obligation shall be ensured by the situational regulation of technological processes in the AA by the established regulations. This is especially important in cases of increased information load in the AIS. Another critical issue is the AA interaction with other entities in a distributed environment of administrative management. It is where interoperability and cybersecurity come to the fore.

Based on the research, the general scheme of the methodology components for constructing the typical analytical system of AA is offered below (Fig. 5).

The methodology is based on the well-known principles of openness and integration into the

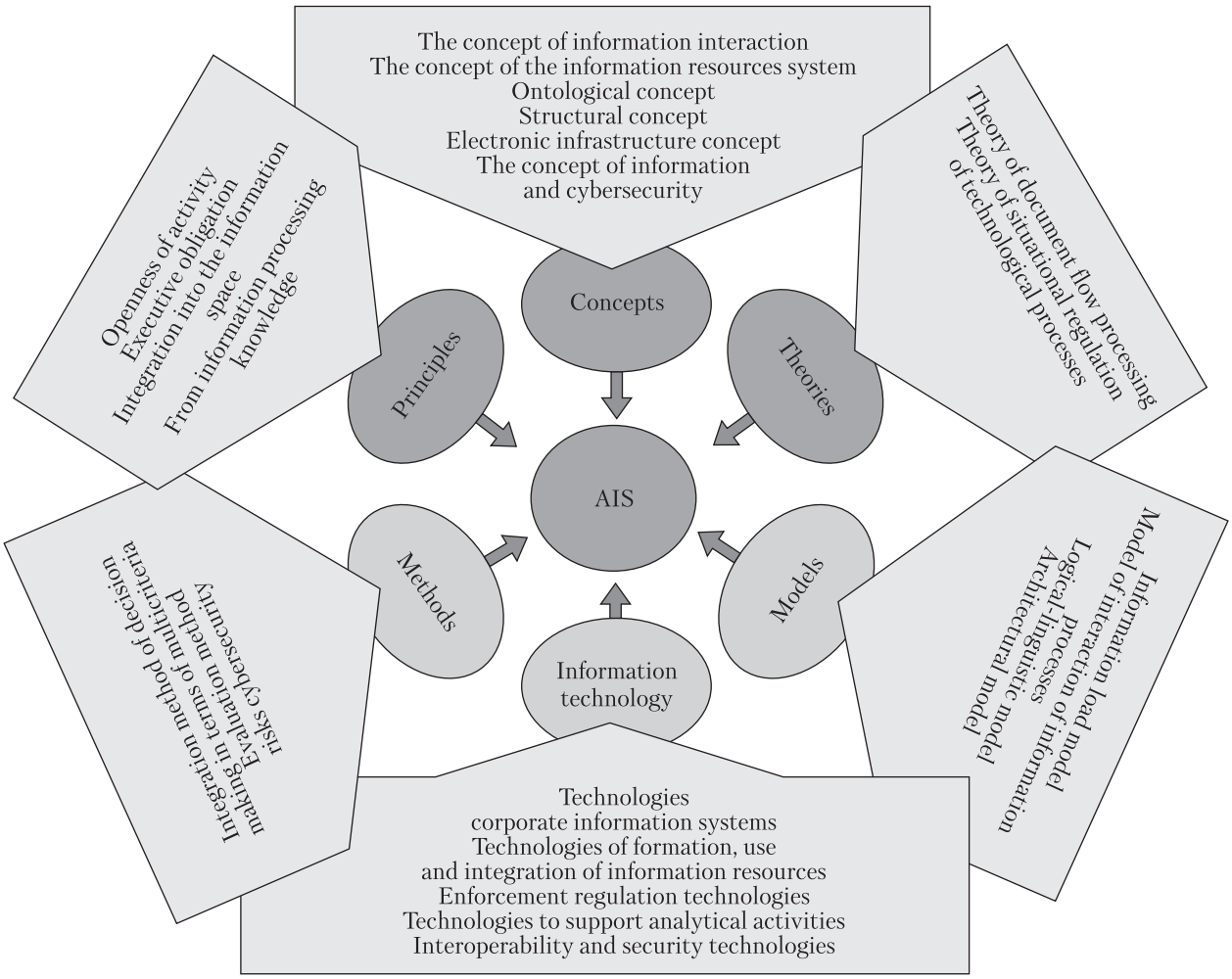


Fig. 5. The general components methodology scheme for building a typical analytical system

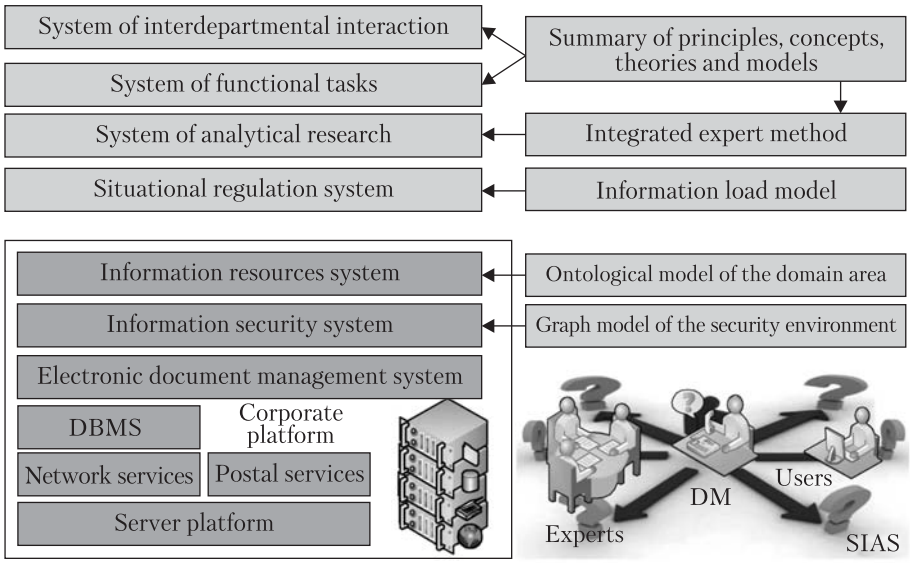


Fig. 6. Technological solutions for building the system of information and analytical support of regional governments (SIAS)

information space, which are supplemented by the principles and paradigms of executive processing of documents, providing AIA based on knowledge-based approach, the intellectualization of AA, as well as the solution of multicriteria problems on the basis of expert methods.

Based on the analysis and estimation of formalization and modeling of AIS, proceeding from the priority of the information approach, conceptual and theoretical bases of designing the system have been formed. Based on this, the design base proposes the concept of AA information interaction, related to the administrative system interaction with the environment, and the concept of information resources of the administrative sphere, based on the requirements for creating and organizing the use of national information resources. It has been also determined by the appropriate use of information models that implement the hypothesis of the patterns of structuring information in its perception (for example, logical linguistic models based on the methodology of growing pyramidal networks) and interaction models of information processes. The problem-oriented methodology for solving information-analytical problems in AIS has been reflected in the concept of AIA support based on ontological descriptions of the subject area and the application of integrated decision-making method in multicriteria.

This method combines ontological models, expert methods of choosing alternatives, and visualization of alternative comparisons, based on the graph representation [21].

For the dominant information unit in the AA being a document, the design of AIS should be found on the provisions of the theory of processing information document flows. This theory takes into account the requirements of the policy of enforcement.

In the general case, this analysis is based on the information theory and the mathematical theory of information distribution (the traffic theory).

Simultaneously, the theory of situational regulation of technological processes in AA shall contain the solution of the problem of measuring the information load with the use of the interpretation of the introductory provisions of the queuing theory.

Possible AIS structures and basic components of its architecture are determined on the basis of

AA and AIS structural concepts and the concept of electronic infrastructure in the field of administrative management, which should form the environment of AIS interaction.

The importance of security issues in the information society, especially for the interoperable systems, is related to the concept of information and cybersecurity, resilience and survivability of AIS, and the method for assessing the cybersecurity risks based on a graph representation of the security environment [22].

Methodological approaches to using information technology in AIS should be based on known methods for creating corporate information systems for enterprise management.

The basic ERP-technologies are supplemented with technologies for supporting analytical activities, namely: the formation, use, and integration of information resources, the regulation of enforcement in electronic document management, and the support of decisions, as well as technologies to ensure interoperability and cybersecurity in a network-centric environment.

The outcome of the research is the solution of practical problems of developing architectural solutions for the construction of separable AIS of government and public authorities of Ukraine. Even though the systems under consideration are designed to solve completely different problems, they are built according to the developed methodology. The systems provide the full-cycle information processing and the creation and maintenance of an information base focused on virtually paperless technology, support a significant amount of analytical calculations, and meet the requirements for the integration of information resources and information security.

The organizational and functional structure of systems, the principles of information interaction of structural elements, and the technological solutions of construction, which correspond to the developed methodology, are most fully presented in the System of information and analytical support of regional management bodies (SIAS). The results of the development have been implemented in the public administrations of Rivne, Donetsk, Cherkasy, Chernihiv, Chernivtsi, Lviv, Luhansk, Ivano-Frankivsk Oblasts, Slavianoserbsk and Starobilsk district public administrations.

The technological solutions for SIAS building are shown in Fig. 6. The technology of collection, accumulation, and analytical processing of information in SIAS is presented in Fig. 7. These IT provide a one-time introduction and formalization of the transfer of information exchange between structural components with the integration within individual functional sections.

The main purpose of SIAS is to provide conditions for making informed, coordinated, and effective decisions to improve the socio-economic situation of the regions. Therefore, the system provides aggregation of all performance indica-

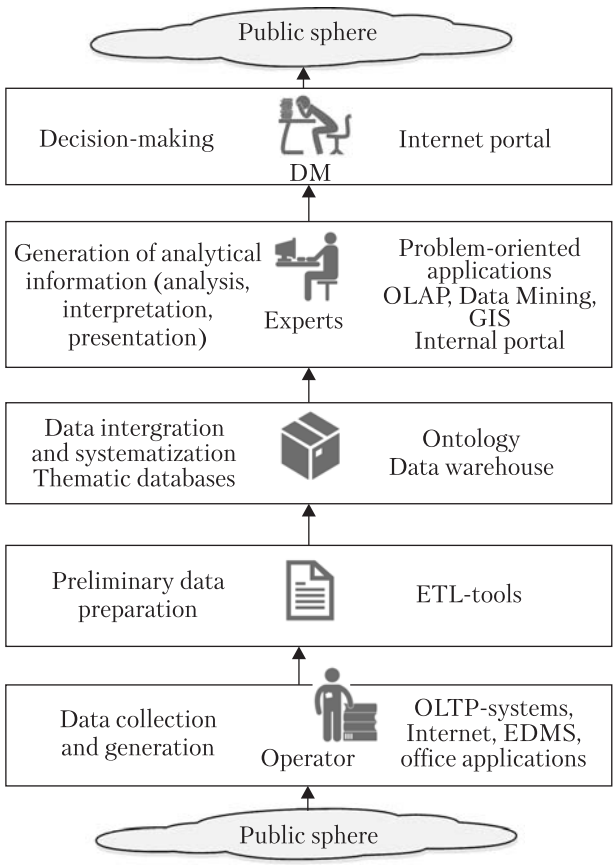
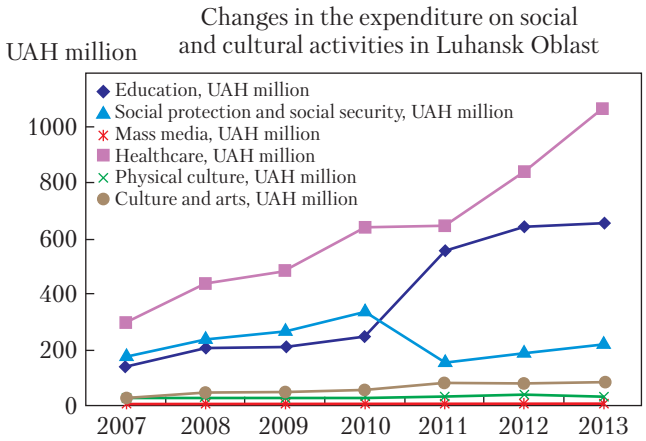
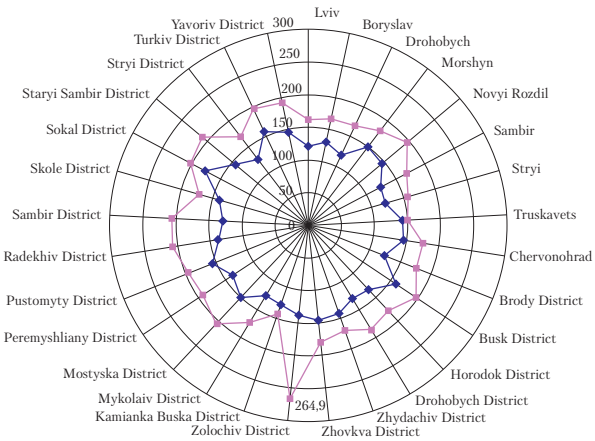
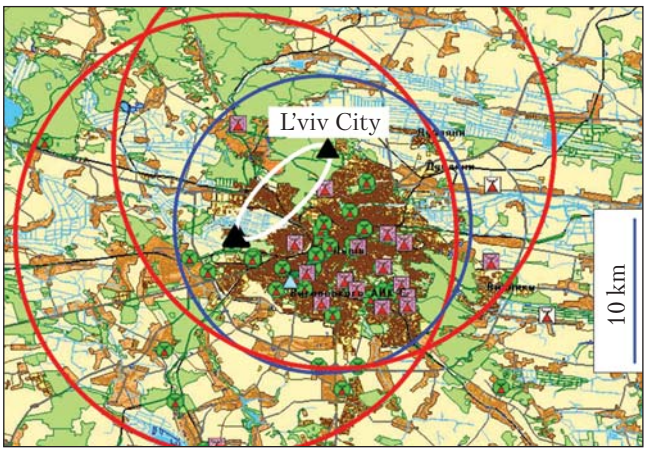


Fig. 7. General scheme of information flow in SIAS

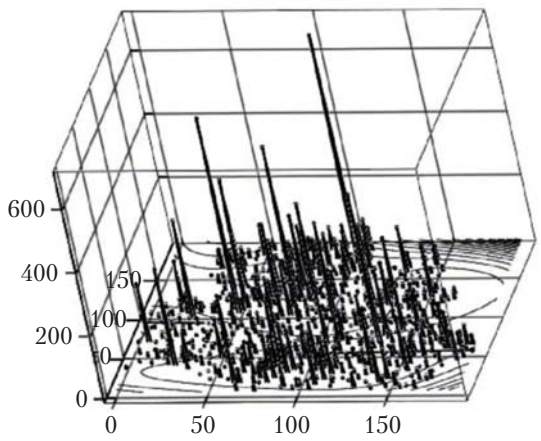






Zones of economic activities of consumer service enterprises in Lviv Oblast

Distribution of the local budget revenues per capita in Lviv Oblast



Analysis of the territorial distribution of the local budget revenues in Lviv Oblast

Fig. 8. Results of the analysis to support decision making in SIAS

tors of business entities into a single repository that is used to create analytical materials, to analyze the financial condition of enterprises, and to provide information to authorized persons.

The SIAS consists of the following main functional parts: the register of economic entities; the classifiers that identify business entities and the indicators of their activities; the data collection and transmission module that interacts between subscribers; the data processing and analytical reporting module. Examples of analytics to support decision-making are shown in Fig. 8.

The theoretical and experimental results obtained in the research have given a new solution of providing information and analytical activities in administrative management. This research is a significant step forward, as it has been implemented in many administrative bodies.

Usually the last procedure for creating information and analytical management systems is technical and economic analysis. For such systems, the efficiency indicator is an integrated result of the interaction of management components, because they consist not only of the effi-

ciency of the very systems but also of the effectiveness of the management process in the body supported by this system. How to choose a system of indicators and how to assess the effectiveness of these questions are far from being clear. It is very difficult to say how to relate such system indicators as productivity, cost, and reliability to the effectiveness of solutions. For example, integrated information resources (databases) are formed with the use of the classifier of socio-economic development indicators that combine indicators from different sources of different levels of government.

Such indicators contain more than 10 thousand names that are described by single reference information consisting of 27 sections on all spheres of life of the regions. Nevertheless, the developed tools allow increasing the productivity of data preparation 2–4 times. Also, the use of geographic information systems and of effective methods for processing space images of certain areas has significantly expanded the capabilities of experts in making appropriate decisions.

In the course of SIAS implementation, it has been noted that the systems allow reducing several times the time spent by users on the construction of reporting materials. SIAS has significantly increased the efficiency and effectiveness of decisions. As a result, due to the widespread implementation of modern information technologies, SIAS not only provides a solution to the problem of improving the efficiency of civil servants and government agencies, but also raises the level of economic development of the regions.

The main requirements for the methodology of creating information systems include efficiency, effectiveness, and scale. It should be noted that these problems have been solved in the research. The methodology is usually based on hypotheses that have also been put forward and used. Finally, such methodologies shall reveal the uncertainties facing system developers. We have to say that the proposed methodology, unlike many other solutions based on the principles of systems analysis, reveals several uncertainties.

First of all, it is the conceptual uncertainty. Further, at this step, there is a disclosure of the situational uncertainty; a simulation of situational regulation of processes has been offered.

The next step is to reveal the information uncertainty, ways to use different types of information, followed by the disclosure of the structural and functional uncertainty. In terms of its formulation, this problem has been solved.

Nevertheless, the main part is the procedural system analysis, where at each level of the created system the tasks of local decision-making are solved; at the highest level, it is done by the decision-maker and the team at the disposal of DM. Decisions are made to the whole system and the problem of management of the whole system has been considered.

It is clear that new technologies and artificial intelligence will generate new problems in creating analytical systems. However, at a high level, this methodology shall demonstrate a system approach and principles of system analysis in the creation of such state-of-the-art systems.

Conclusions

The research proposes developing a methodology for creating information analytical systems in administrative management, given the requirements of complexity, support for management decisions based on knowledge-oriented tools, their comprehensive information support, support for document processing, information, and cybersecurity.

The novelty of the results is the fact that the important problem of the synthesis and design of automated systems of information-analytical support as a basis for the development of information space infrastructure in the field of administrative management has been solved. The main scientific contributions of this research include:

1) a comprehensive methodology for building a typical analytical system in the field of administrative management based on a set of principles, concepts, theories, methods and models, as well as information technology has been developed;

2) the theoretical framework is the regulations for processing document flows in administrative bodies, which are based on the requirements established in the policy of enforcement;

3) the fundamentals of the new theory of situational regulation of document processing technology processes have been elaborated;

4) approach to overcoming the multicriteria problem in decision-making support based on the integration of the ontological modeling of the problem area, the expert method for evaluation and selection of alternatives (the analytical hierarchy process) and the visualization on graphs of pairwise comparisons has been proposed;

5) the integration paradigm of information and analytical systems and information resource on the basis of a single platform for interoperability and cybersecurity has been described.

The methodological approaches to using information technology in AIS are based on well-known methods for creating corporate information systems for enterprise management, which have been supplemented with new technologies to support analytical activities.

The practical significance of obtained results is creating a scientific and methodological framework for building analytical information systems in various areas of administrative management.

The prospects for further research are to create universal and specialized tools for informatization of administrative bodies with increased efficiency for a wide range of practical problems.

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REFERENCES

1. Nesterenko, O., Trofymchuk, O. (2019). Patterns in forming the ontology-based environment of information-analytical activity in administrative management. *Eastern-European Journal of Enterprise Technologies*, 5(2), 33–42. https://doi.org/10.15587/1729-4061.2019.180107.
2. Gal, U., Riemer, K., Chasin, F. (2018). A Historical Perspective on Information Systems: A Tool and Methodology for Studying the Evolution of Social Representations on Wikipedia. *Communications of the Association for Information Systems*, 43, 711–750. https://doi.org/10.17705/1CAIS.04337
3. Walton, P. (2019). Information Evolution and Organisations. *Information*, 10(12), 29. https://doi.org/10.3390/info10120393
4. Michalczyk, S., Scheu, S. (2020). Designing an analytical information systems engineering method. *28th European Conference on Information Systems (ECIS 2020) (15-17 June 2020, Morocco*). Marrakesh, Morocco, 57–61.
5. Manteghia, N., Jahromib, S. (2012). An Overview of Systems Design and Development Methodologies with Regard to the Involvement of Users and Other Stakeholders, *Procedia Technology*, 1, 308–312.
6. Schoormann, T., Kutzner, K. (2020). Towards Understanding Social Sustainability: An Information Systems Research-Perspective. *Forty-First International Conference on Information Systems ICIS 2020 (13–16 December, 2020, Hyderabad)*. Hyderabad, India, 1–17.
7. Pelizza, A. (2021). Towards a sociomaterial approach to inter-organizational boundaries: How information systems elicit relevant knowledge in government outsourcing. *Journal of Information Technology*, 36(2), 94–108. https://doi.org/10.1177/0268396220934490.
8. Liu, X., Werder, K., Mädche, A. (2016). A Taxonomy of Digital Service Design Techniques. *Thirty Seventh International Conference on Information Systems, ICIS 2016* (*11–14 December, 2016, Dublin)*. Dublin, Ireland, 1–12.

9. Senivongse, C., Bennet, A., Mariano, S. (2017). Utilizing a systematic literature review to develop an integrated framework for information and knowledge management systems. *VINE Journal of Information and Knowledge Management Systems*, 47(2), 250–264. https://doi.org/10.1108/VJIKMS-03-2017-0011.
10. Osypenko, V., Lurie, I., Yakobchuk, M., Savina, N., Boskin, O., Lytvynenko, V. (2019). About Innovation-Investment Designing of Complex Systems by Inductive Technology of System Information-Analytical Research. *Proceedings of the 2019 10th IEEE international conference on intelligent data acquisition and advanced computing systems — technology and applications (IDAACS) (18–21 September, 2019, Metz*). Metz, France, 1, 424–430. https://doi.org/10.1109/IDAACS.2019.8924434
11. Sandkuhl, K., Seigerroth, U. (2019). Method engineering in information systems analysis and design: a balanced scorecard approach for method improvement. *Software & Systems Modeling*, 18, 1833–1857. https://doi.org/10.1007/s10270-018-0692-3.
12. Novak, A., Bashtannyk, V., Parkhomenko-Kutsevil, O., Kuybida, V., Kobyzhcha, N. (2021). Information and Analytical Support of Anti-Corruption Policy. *International journal of computer science and network security*, 21(3), 134–140. https://doi.org/10.22937/IJCSNS.2021.21.3.18.
13. Dalain, Ali F. (2019). Development methods of implementing analytical management information systems for technological monitoring of complex industrial purposes. *International journal of computer science and network security*, 19(4), 79–86. https://doi.org/10.22937/IJCSNS.2019.19.4.14.
14. Bouafia, Kh., Molnar, B. (2019). Analysis approach for enterprise information systems architecture based on hypergraph to aligned business process requirements. *International Conference on ENTERprise Information Systems (CENTERIS) / International Conference on Project MANagement (ProjMAN) / International Conference on Health and Social Care Information Systems and Technologies (HCist) (16–18 October, 2019, Sousse)*. Sousse, Tunisia, 164, 19–24. https://doi.org/10.1016/j.procs.2019.12.149
15. Nalchigar, S., Yu, E. (2020). Designing Business Analytics Solutions. *Business & Information Systems Engineering*, 62(2), 1–15. https://doi.org/10.1007/s12599-018-0555-z.
16. DeStefano, R. J., Tao, L., Gai, K. (2016). Improving Data Governance in Large Organizations through Ontology and Linked Data. *IEEE 3rd International Conference on Cyber Security and Cloud Computing (25–27 June 2016, Beijing)*. Beijing, China, 279–284. https://doi.org/10.1109/CSCloud. 2016. 47.
17. Almeida, M. B., Pessanha, C. P., Barcelos, R. (2017). *Information Architecture for Organizations: An Ontological Approach*. In book: Ontology for Information Science: Intech Publisher: Editors: Ciza Thomas.
18. Fill, H.-G. (2020). Enterprise Modeling: From Digital Transformation to Digital Ubiquity. *Federated Conference on Computer Science and Information Systems (6–9 September, 2020, Sofia)*. Sofia, Bulgaria, 1–4. https://doi.org/10.15439/2020F001.
19. Krijnen, C. (2017). *What is Organization? From Organization Theory to Organizational Ontology.* In book: The Very Idea of Organization. Series: Critical Studies in German Idealism, 16, 9–34.
20. Nesterenko, O. (2021). Ontology and Analytic Hierarchy Process in the information and analytical systems. *Lecture notes in computational intelligence and decision making. Chapter No: 19 (Eds. S. Babichev et al.) ISDMCI 2020, AISC 1246*, Springer, 302–314. https://doi.org/10.1007/978-3-030-54215-3_19.
21. Nesterenko, O., Netesin, I., Polischuk, V., Trofymchuk, O. (2020). Development of a procedure for expert estimation of capabilities in defense planning under multicriterial conditions. *Eastern-European Journal of Enterprise Technologies*, 4(2), 33–43. https://doi.org/10.15587/1729-4061.2020.208603.
22. Nesterenko, A., Netesin, I. (2020). Cybersecurity graph model of information resources. *Journal of automation and information sciences*, 52(8), 14–31. https://doi.org/10.1615/JAutomatInfScien.v52.i8.20.

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МЕТОДОЛОГІЯ ПРОЄКТУВАННЯ ІНФОРМАЦІЙНО-АНАЛІТИЧНИХ СИСТЕМ АДМІНІСТРАТИВНОГО УПРАВЛІННЯ

Вступ. У сфері адміністративного управління інтенсивність управлінської діяльності та обсяг інформації, яку необхідно обробити для прийняття рішень, постійно зростають. У цих умовах використання нових інформаційних технологій в аналітичній інформаційній діяльності адміністративних органів та побудова відповідних автоматизованих систем має особливе значення.

Проблематика. Існує гостра потреба у новому підході до вирішення питань розвитку аналітичної інформаційної діяльності та автоматизації діяльності адміністративних органів, який має ґрунтуватися на інформації, розглядати сучасне уявлення про інформацію як інтелектуальний продукт — знання як ресурс суспільства, та базуватися на забезпеченні складності рішень.

Мета. Розроблення методології проєктування аналітичних систем на основі інтеграції концепцій, моделей, методів та інформаційних технологій з урахуванням вимог складності рішень.

Матеріали й методи. Методологія базується на концепціях, моделях, методах та інформаційних технологіях з урахуванням вимог складності, підтримки управлінських рішень на основі знання-орієнтованих інструментів, їх всебічного інформаційного забезпечення, підтримки обробки документів, інформаційної та кібербезпеки, а також інтеграція аналітичних інформаційних систем з функціональною сумісністю.

Результати. На основі проведеного дослідження запропоновано приклад методології побудови типової інформаційно-аналітичної системи адміністративних органів, яку може бути використано при побудові автоматизованих систем в різних органах управління, зокрема для забезпечення регіонального урядування.

Висновки. Теоретичним підґрунтям є положення про обробку документообігу в адміністративних органах на основі вимог політики застосування. Практичне значення отриманих результатів полягає у створенні науково-методологічної бази для побудови аналітичних інформаційних систем у різних сферах адміністративного управління.

Ключові слова: інформаційно-аналітична система, підтримка прийнятих рішень, адміністративне управління, онтологія, метод аналізу ієрархії.