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RESEARCH METHODOLOGY OF TRAFFIC FLOW AND INFRASTRUCTURE OBJECTS INTELLIGENT MANAGEMENT

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Abstract. *The article presents the main approaches to the research of intelligent traffic management and infrastructure facilities. The aim of research is theoretical and methodological foundations development, and also the practical recommendations development in the intelligent management field of transport flows and infrastructure objects. The conceptual elements of intellectual management methodology are investigated. The notion of intellectual management methodology is clarified. The approaches to the transport and of infrastructure objects intelligent management at the micro-, meso- and macro level are considered. The conceptual elements of intellectual management methodology are generalized, which it allowed to combine into a whole the philosophy, ideology, strategy, methodology, technologies into a management system, which forms the methods, ways and tools of traffic flows and infrastructure objects management. With the aim to ensure the sustainable development of intellectual transport management, the formation expediency of an individual system of principles is justified. The author proposed to consider of intellectual management through the prism of value, system, process and result. The conceptual elements of intellectual management methodology are analyzed. Methodological and conceptual approaches of traffic flows and infrastructure facilities intelligent management have allowed us to develop a scheme for intelligent management implementation at the transport enterprise. The developed stages of intellectual system modeling at the transport enterprise allow, taking into account the system approach principles, accepted backgrounds and general concept of traffic flows and infrastructure objects intelligent management, to determine the main set of elements of a modeling system, to establish relationships between them, to ensure consistency and to increase the reliability of management decisions.*

Keywords: *intelligent management; intelligent transport systems; methods; management methodology; transport.*

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МЕТОДОЛОГІЯ ДОСЛІДЖЕННЯ ІНТЕЛЕКТУАЛЬНОГО УПРАВЛІННЯ ТРАНСПОРТНИМИ ПОТОКАМИ ТА ОБ'ЄКТАМИ ІНФРАСТРУКТУРИ

Катерна, О. К. Методологія дослідження інтелектуального управління транспортними потоками та об'єктами інфраструктури // Вісник соціально-економічних досліджень : зб. наук. праць (ISSN 2313-4569); за ред. : М. І. Звєрякова (голов. ред.) та ін. Одеса : Одеський національний економічний університет. 2018. № 3 (67). С. 80–90.

Анотація. *У статті представлено основні підходи до проведення дослідження інтелектуального управління транспортними потоками та об'єктами інфраструктури. Метою дослідження є розвиток теоретичних і методологічних основ, а також розробка практичних рекомендацій в області інтелектуального управління транспортними потоками та об'єктами інфраструктури. Досліджено концептуальні елементи методології інтелектуального управління. Розглянуто підходи до інтелектуального управління транспортом і об'єктами інфраструктури на мікро-, мезо- та макрорівні. Узагальнено концептуальні елементи методології інтелектуального управління, що дозволило об'єднати в єдине ціле філософії, ідеології, стратегії, методології, технології в систему управління, яка формує методи, способи і інструменти управління транспортними потоками та об'єктами інфраструктури. З метою забезпечення сталого розвитку інтелектуального управління на транспорті обґрунтовано доцільність формування індивідуальної системи принципів. Автором запропоновано розглядати інтелектуальне управління через призму цінності, системності, процесу та результату. Проаналізовано*

концептуальні елементи методології інтелектуального управління. Запропоновані методологічні та концептуальні підходи інтелектуального управління транспортними потоками та об'єктами інфраструктури дозволили розробити схему впровадження інтелектуального управління на транспортному підприємстві. Розроблені етапи моделювання інтелектуальної системи на транспортному підприємстві дозволяють з урахуванням принципів системного підходу, прийнятих передумов і загальної концепції інтелектуального управління транспортними потоками та об'єктами інфраструктури, визначити основний набір елементів системи моделювання, встановити взаємозв'язки між ними, забезпечити узгодженість і підвищити надійність прийнятих управлінських рішень.

Ключові слова: інтелектуальне управління; інтелектуальні транспортні системи; методи; методологія управління; транспорт.

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МЕТОДОЛОГИЯ ИССЛЕДОВАНИЯ ИНТЕЛЛЕКТУАЛЬНОГО УПРАВЛЕНИЯ ТРАНСПОРТНЫМИ ПОТОКАМИ И ОБЪЕКТАМИ ИНФРАСТРУКТУРЫ

Катерная, О. К. Методология исследования интеллектуального управления транспортными потоками и объектами инфраструктуры // Вестник социально-экономических исследований : сб. науч. трудов (ISSN 2313-4569); под ред. : М. И. Зверякова (глав. ред.) и др. Одесса : Одесский национальный экономический университет. 2018. № 3 (67). С. 80–90.

Аннотация. В статье представлены основные подходы к проведению исследования интеллектуального управления транспортными потоками и объектами инфраструктуры. Целью исследования является развитие теоретических и методологических основ, а также разработка практических рекомендаций в области интеллектуального управления транспортными потоками и объектами инфраструктуры. Исследованы концептуальные элементы методологии интеллектуального управления. Уточнено понятие методологии интеллектуального управления. Рассмотрены подходы к интеллектуальному управлению транспортом и объектами инфраструктуры на микро-, мезо и макроуровне. Обобщены концептуальные элементы методологии интеллектуального управления, что позволило объединить в единое целое философии, идеологии, стратегии, методологии, технологий в систему управления, которая формирует методы, способы и инструменты управления транспортными потоками и объектами инфраструктуры. С целью обеспечения устойчивого развития интеллектуального управления на транспорте обоснована целесообразность формирования индивидуальной системы принципов. Автором предложено рассматривать интеллектуальное управление через призму ценности, системности, процесса и результата. Проанализированы концептуальные элементы методологии интеллектуального управления. Предложенные методологические и концептуальные подходы интеллектуального управления транспортными потоками и объектами инфраструктуры позволили разработать схему внедрения интеллектуального управления на транспортном предприятии. Разработанные этапы моделирования интеллектуальной системы на транспортном предприятии позволяют с учетом принципов системного подхода, принятых предпосылок и общей концепции интеллектуального управления транспортными потоками и объектами инфраструктуры, определить основной набор элементов системы моделирования, установить взаимосвязи между ними, обеспечить согласованность и повысить надежность принятых управленческих решений.

Ключевые слова: интеллектуальное управление; интеллектуальные транспортные системы; методы; методология управления; транспорт.

JEL classification: F200; L860; L900; O100; R410

1. Introduction

In the world scientific community there is a constant interest to improving and developing a new technologies and control systems for transport on the basis of intelligent systems. Improvement both existing and new approaches, paradigms and algorithms (methods) formation of intelligent management is inextricable connection with scientific and technological progress, including the «intelligent» systems.

With the expansion of information systems and technologies in all sectors of the country's economy, including socio-cultural, which include transport, intelligent transport systems becoming increasingly important. The basis of intelligent management is use of intelligent systems that have emerged as a means of overcoming a number of information barriers and that allow you to obtain results that are not typical of conventional information systems.

The object of research is the methodology of intelligent management of traffic flows and objects of infrastructure.

The modern paradigm of management in the transport sector involves the use of innovative developments, which leads to the need to study the conceptual elements of the methodology of intelligent management.

The paradigm shift in innovation and technological development at a new stage determines the relevance of research into theoretical, methodological and practical problems of the interconnected development of the science of intelligent management and innovation in order to search for optimization and to improve the efficiency of management of transport flows and objects of infrastructure.

The use of intelligent systems in transport is primarily systemic changes aimed at providing various innovative services on various modes of transport, achieving sustainable mobility through increased efficiency, safety and environmental compatibility of transport. Research of the methods in the field of intelligent transport management for Ukraine can be considered, on the one hand, adaptation to foreign experience, on the other hand – the product of its own intelligent resources.

The aim of the research is development of theoretical and methodological foundations, as well as development of practical recommendations in the field of intelligent management of transport flows and objects of infrastructure.

To achieve the goal of study, the following scientific objectives have been identified:

1. Conduct an analysis of modern approaches in the field of methodology of intelligent management.
2. Form the basic elements of intellectual management, taking into account the complexity and dynamism of knowledge and process of management of transport flow and objects of infrastructure.
3. Identify the stages of intelligent management modeling in the enterprise.

During the execution of the research general scientific and special research methods were applied:

- analysis and synthesis – research of the modern paradigm of intelligent management; the formation of background, principles, approaches, levels, aspects and methods in the overall system of conceptual elements of the methodology of intelligent management. The combination of methods of analysis and synthesis ensured a systematic approach to the analysis of complex objects of research;
- system analysis – research of practical problems of intelligent management in transport associated with the creation of new and modernization of existing systems. Allowed to consider intelligent management as a system, to determine the connections between its elements.

2. Analysis of research and publications of recent years

In modern native and foreign economic and technical literature, emphasis on a problem is paid to the management of complex systems based on intelligent systems.

So, the works of such scientists is worth noticing: V. M. Markelov, I. V. Solovyov, V. Ya. Tsvetkov (2014) [1], Ye. Yu. Kandrashin, L. V. Litvintseva, D. A. Pospelov (1989) [2], V. I. Donsky (2014) [3], D. O. Novikov (2011) [4], V. V. Glushchenko, I. I. Glushchenko (2009) [5; 6], Yu. M. Plotinsky (1998) [7], V. V. Skalozub, V. M. Ilman (2013) [8], M. G. Mamedova, F. R. Mamedzade (2015) [9], A. B. Ponomarev and E. A. Pikuleva [10] etc.

Mentioned above field of research, as specialists note, currently is one of the most promising and popular, first of all, from a concrete practical point of view – how to manage transport flows and objects of infrastructure and how to organize their interaction in order to increase the efficiency and competitiveness of the enterprise.

3. Problem description

The problems of the research methodology are timely for any science, especially in the modern world, when in connection with scientific and technical breakthroughs and the emergence of artificial intelligence. Scientists have to solve both complex tasks and design mechanisms for their solution.

Argument, that the interest of modern science to the problems of methodology is particularly great, is the fact of the emergence of a special branch of knowledge within philosophy, namely logic and methodology of scientific research: D. O. Novikov (2011) [4], Yu. M. Plotinsky (1998) [7], V. V. Glushchenko, I. I. Glushchenko (2009) [5; 6], V. V. Skalozub, V. M. Ilman (2013) [8] and others.

On the one hand, today in the scientific literature the questions of the methodology of scientific activity (the methodology of scientific research) of enterprise management are fully considered [4; 5; 8], and on the other hand the questions of the methodology of intelligent management are not sufficiently disclosed.

4. The main material research

Before talking more specifically about methods of intelligent management, it is necessary to clarify what is generally meaning by methodology.

Management methodology is a logical scheme of management activity, providing for an interrelated understanding of goals, tasks, and also the means and ways to achieve them. It is also the ability to see, recognize, understand, evaluate and consider addictions, and reveal the content of problems, and suggest ways to solve them. Thus, management methodology is a doctrine of the organization of management activities, that is, the activities of entities that manage other subjects or objects [4, p.16].

Specialists identify the following components that characterize the content of management methodology: approaches, paradigms, problems, priorities, benchmarks, criteria, alternatives, selection procedures, means and methods of management, and limitations.

Ponomarev A.B. and Pikuleva E.A. presented methodology as a doctrine of the structure of a logical organization, methods and means of activity (the doctrine of the construction principles, forms and methods of research activity) [10, p.24].

Methodology of science, in their opinion, gives a description of the components of scientific research – its object, the subject of analysis, the task of research (or problem), the totality of research of the means necessary for solving this type of problem, and also forms an idea of the sequence of the movement of the research in the process of accomplishing the task. The most important in methodology is the statement of the problem, the construction of the research subject, the construction of the scientific theory, and also the verification of the result obtained from the point of view of its truth.

Markelov V. M., Solovyov I. V., Tsvetkov V. Ya. (2014) argue that more development of the management methodology has occurred mainly in three areas: the expansion of classes and types of optimal control tasks, the complexity of management systems, the integration of previously qualitatively different management methods into a single complex [1, p.42]. One has to agree with the point of view of scientists, the modern integration of various management methods into a single complex with the growth of complexity and information volumes is possible only with the use of intelligent systems.

The developments of telematics and information technology have an impact on the use of new methods for managing transport flows and objects of infrastructure. The space technologies development has an impact on the appearance of methods of navigational monitoring, which, as noted by I. V. Solovyov, V. Ya. Tsvetkov in their work [11], require the use of intelligent solutions. Scientists note that intelligent management is effectively implemented only in the information space, aims to create an information environment in the transport sector, which allows efficient and in a timely manner control of transportation and traffic safety.

Donskoy V. I. writes that intelligent management is an interesting field of application of theoretical cybernetics in modern information systems [3, p.22]. Mathematical methods applied in problems of intelligent management are determined, basically, by the nature of the control object and the environment – their features and complexity. Complexity of controlled objects can be so high that direct application of some mathematical methods becomes practically impossible. If, in addition, there is an uncertainty of the initial information available for the development of control actions, then mathematical methods that allow such uncertainty are required, and this is the methods of artificial intelligence: learning, knowledge management, recognition, prediction. In all cases, to any extent, applications of (probably specific) optimization methods will be required.

Novikov D. O. in his scholarly research [4, p.7] proposes the following «scheme of management methodology»:

1. Characteristics of management activities: its features and principles.
2. Logical structure of management activity, including: entity, objects, subject, forms, means, methods and result of management activity.
3. Temporary structure of management activities – its phases, steps and stages.

Glushchenko V. V., Glushchenko I. I. [6, p.14] distinguishes the following principles of the management methodology:

- on the management of the object is influenced by the systematic nature of the research (external and internal) factors;
- to maximization of the effect and/or the minimization of costs and risks is influenced by the orientation of the management process;
- objectivity and impartiality of assessments of financial management conditions and their trends in the future;
- honesty of carrying out and interpretation of the results of a financial management study (subject, object, process, financial result);
- the practical applicability of methodological results in technologies and management systems;
- effectiveness of methodological research is defined as the requirement that the expenditure of resources on methodological research in management should pay off (additional profit, a reduction in the costs of resources, risks, etc.) received management results etc.

In the scientific research «Improvement of philosophy and methodology of science, management and prognostication: the paradigm of intelligent management», authors V. V. Glushchenko, I. I. Glushchenko under the paradigm of intelligent management, understand the systemic (i.e., harmonious) unification of philosophy, ideology, politics, strategy, tactics, methodology, technologies and management systems into a single whole, which forms methods, methods and tools for managing a particular object under given conditions [5, p.26].

Based on research studies devoted to this problem, the author has identified the following conceptual elements of the methodology of intelligent management, presented in Fig. 1.

- suppositions of the emergence of this area of management;
- methodological approaches to the analysis of the field of intelligent management;
- levels of intelligent management;
- the basic principles of intellectual activity and its aspects, which take into account the complexity and dynamism of knowledge and the management process;

- aspects of intelligent management;
- methods of intelligent management.

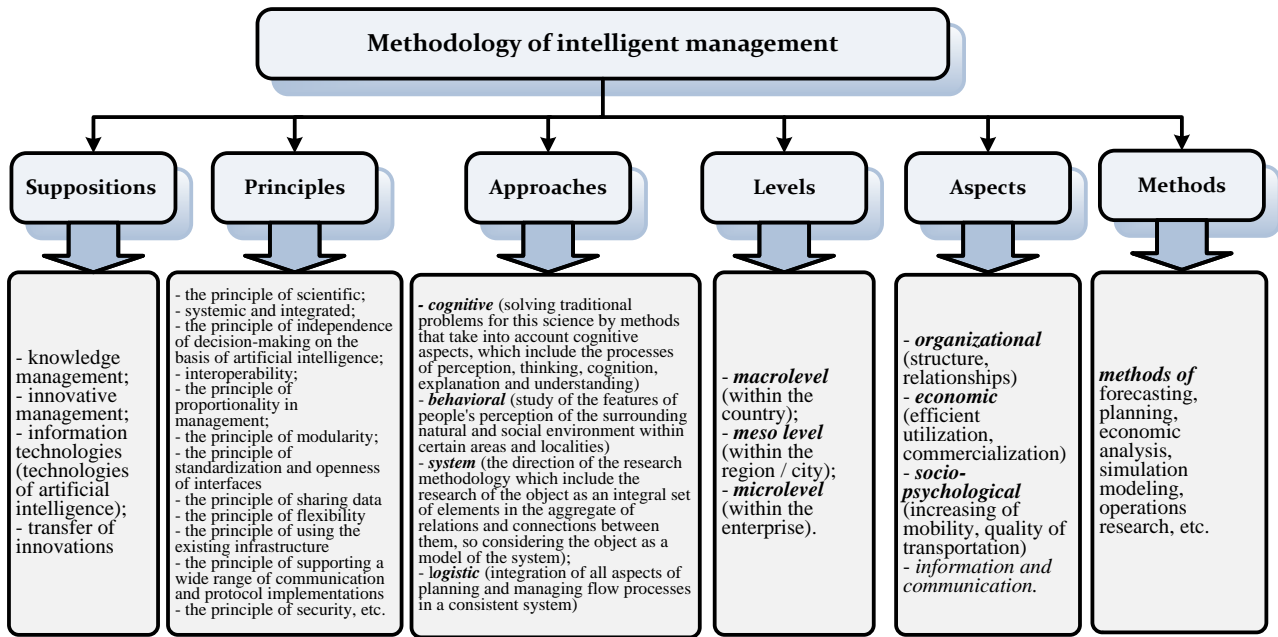


Fig. 1. Conceptual elements of the methodology of intelligent management
Source: [developed by author]

It is necessary to consider the concept of transport intelligent management and objects of infrastructure at various levels:

- 1) transport management at the micro level is appropriate:
 - transport management systems at the level of an individual enterprise (cars, aircrafts, trains, etc.);
- 2) at the mesolevel under the management is considered:
 - management of individual transportation hub and terminals, which coordinate the work of many transport enterprises / institutions (airport, bus station, railway port, seaport, etc.);
 - maintenance of individual transport networks (channels, pipelines, waterways, etc.);
- 3) at the macro level, management includes:
 - transport management as a national economy / economy sector (investment in the industry, industry development, support of safety standards, etc.);
 - management of transport infrastructure.

Thus, depending on the scale of the research, intelligent management acquires its own specific features. The most difficult direction is the macrolevel, however, without effective management at the microlevel, one cannot speak of the possibility of constructing a properly functioning macrosystem. Within certain areas of intellectual management, we can identify a specific specificity, depending on the mode of transport and other approaches to their classification.

The principles reflect the requirements for intelligent management. Ensuring the sustainable development of intelligent management on transport is possible if the following basic principles are observed:

- The principle of complexity assumes a solution by one system or its component of the most possible range of tasks. This principle determines the optimal organization of ITS.
- The principle of architectural unity of local projects determines the requirement to develop local ITS projects on the basis of the National Architecture and thereby reduces the costs required for the deployment of the first stage systems and increasing of their capabilities, including through the integration of systems.

- The principle of interoperability requires the provision of automatic interaction of local ITS operating in one or the neighboring territories, as well as on-board telematic terminals with systems serving different territories. An important component of interoperability is the ability to increase the capabilities of the system.
- The principle of modularity. The functionality of the user services must be distributed among the modular components in order to increase reliability, provide scalability and accommodate different needs.
- The principle of standardization and openness of interfaces. User interfaces should be standardized.
- Principle of data sharing by components of ITS subsystems. Data availability is provided through the functionality of database services that support data sharing.
- The principle of flexibility in system projects and operations ensures compliance with regional preferences. For example, systems can support both centralized and distributed traffic control strategies to provide different benefits and existing infrastructures.
- The principle of using the existing infrastructure ensures the use of already deployed systems and their components.
- The principle of supporting a wide range of communication facilities and protocol implementations. The ITS architecture should include a communication subsystem that isolates communication applications from another part of the architecture.
- The principle of portability of ITS technical solutions, primarily their software, is realized by minimizing the dependence of systems on a particular hardware implementation.
- The principle of ITS security is realized through delineation of access to data, user authentication, depersonalization of data (if it is necessary), adoption of organizational, technical and other measures for protecting information;
- The principle knowledge elicitation and use of new discoveries requires the accumulation of information on the movement of vehicles, their constant analysis and the identification of regularities in order to develop and improve methods and means of optimization, as well as modeling of transport processes;
- Orientation to the domestic manufacturer requires the consideration of national transport and information security. Customers should focus on domestic solutions of similar functionality during development and implementation of ITS.

The presented principles are described in detail in the «Concept for the Development of Intelligent Transport Systems of the Russian Federation» [12], published in 2014.

An important conceptual element of the methodology of intellectual management is methods that disclose the methods that are used in organizational activities, that is, indicate how it is implemented. Solving any task of management, the methods serve the purposes of practical management, providing a system of rules, techniques and approaches that reduce the expenditure of time and other resources on goals setting and achieving.

Intelligent transport management provides for the solution of a large number of interrelated tasks, ranging from planning its activities to the future and ending with the regulation of individual work processes during the implementation of tasks. The solution of these problems is based on the application of economic, organizational, administrative and socio-psychological management methods.

Intellectual management of transportation provider in the context of practical managerial activity is a special kind of coordinating, organizing, stimulating and analytical activity carried out within the framework of the general strategy of the enterprise or the country.

Today we can already talk about the formation of a new form of management – intellectual, in other words, management based on intelligent systems and technologies. According to V. M. Markelov, I. V. Solovyov, V. Ya. Tsvetkov (2014) [1, p.43] the property of intellectuality is manifested in the following:

- obtaining operational decisions in a short space of time, during which a person is unable to develop and make a decision;
- obtaining new solutions and accumulating experience using it in the future;
- the solution of complex problems, the level of complexity of which excludes the possibility of their solution by human.

In the author's opinion, intelligent management should be considered as a system consisting of four components: value, system, process and result (Fig. 2).

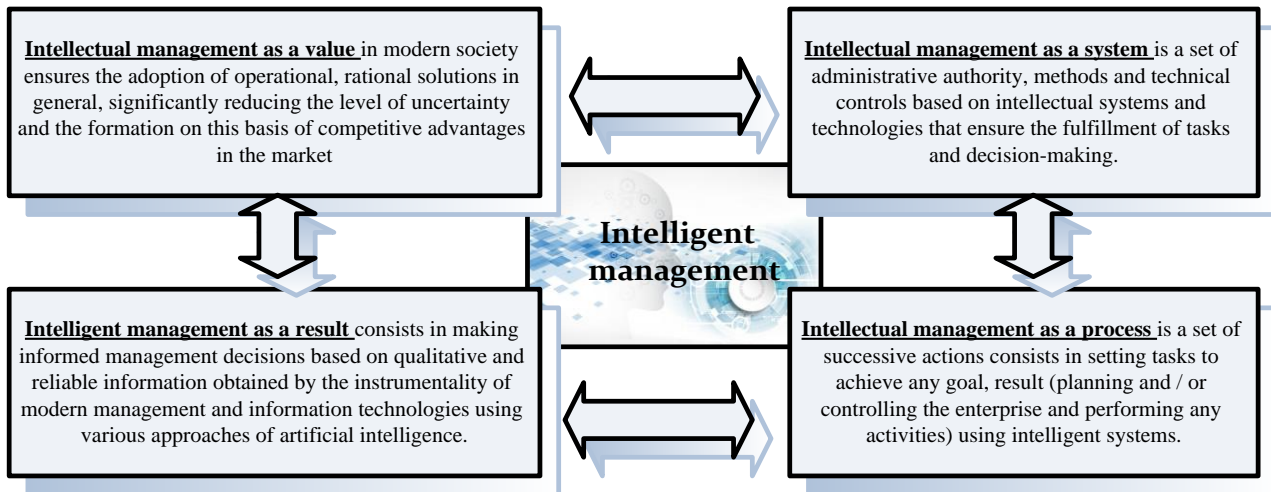


Fig. 2. Components of intelligent management

Source: [developed by author]

The process of intelligent management can be sequential, synchronous parallel, etc., with the intellectual system in most cases can independently perform the actions. In particular, the development of the program of intelligent management of the system's ability to perform is one of the essences of management.

It is known that the solution of research and technological problems requires knowledge of the subject matter, methods of conducting research. The scheme of modeling of intellectual management in the transport enterprise is giving below (Fig. 3).

Skalozub V. V. and Ilman V. M. consider that the search for numerous solutions to optimal control problems requires, as a rule, the development of a non-standard algorithm or the transformation of a task to a typical one for which standard calculation procedures exist. Therefore, algorithms for solving typical problems of optimal control should be included in intelligent transport systems [8, p.65] (transport problem, network diagram etc.). But according to international experience artificial intelligence is at the heart of intellectual management in transport [13; 14].

The author suggests considering the following stages of modeling of intelligent management in transport.

So at the first stage, the system is identified, its subject area, which follows from the consideration of the role of the subsystem. The elements of the system are determined between the communication elements of the system, the internal parameters of the system. Further, based on the system approach, external input, output factors and parameters are determined, which weigh with the system and the external environment. This allows us to investigate the properties of the system and its components. Then the state of the system, its functioning, the influence of parameters on the quality of functioning, the uncertainty of the system are examined and at the end of the first stage the existing management and the need for the organization of the intellectual are analyzed. Then the state of the system is examined, its functioning, the influence of parameters on the quality of

functioning, the uncertainty of the system, and at the end of the first stage, the existing management and the need for the organization of the intellectual are analyzed.

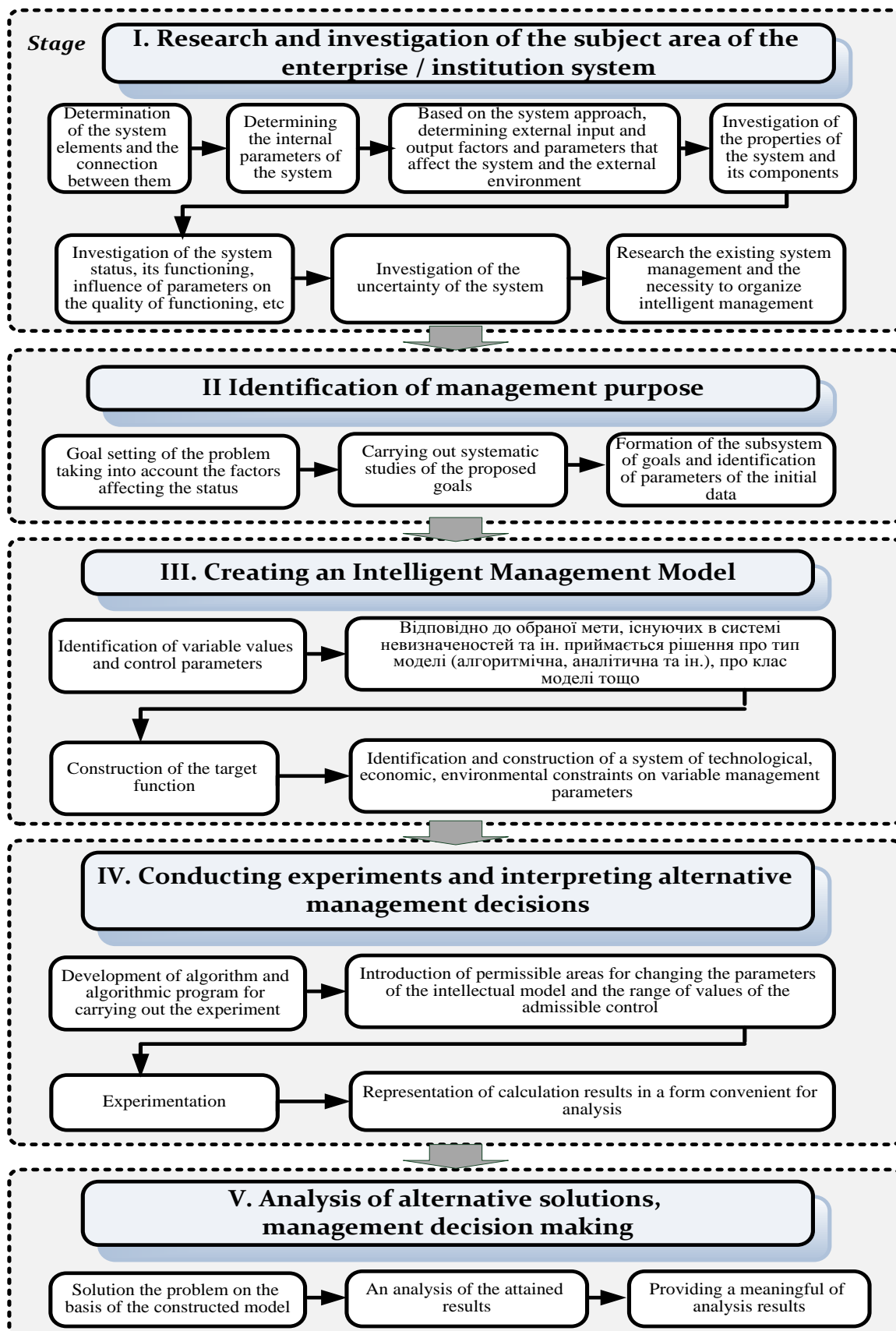


Fig. 3. The scheme of modeling of intelligent management in the enterprise
 Source: [developed by author]

The second stage consists in the construction and analysis of the tree of objectives.

At the third stage, a model of intelligent management is constructed, where variables and control parameters are defined. Further, according to the chosen goal, existing in the uncertainty system, a decision is made about the type of the model (algorithmic, analytical, etc.), about the model class. This allows you to create a target function and define a system of technological, economic, environmental constraints.

The fourth stage is devoted to conducting experiments and interpreting alternative management decisions. The stage is characterized by the development of the algorithm and algorithmic program for conducting the experiment, the introduction of permissible areas for changing the parameters of the intellectual model and the range of values of permissible control, conducting experiments, and presenting the results of calculations in a form convenient for analysis.

At the last fifth stage, alternative solutions are analyzed and managerial decisions are made. To this, tasks based on the constructed model are solved, the results are analyzed and a meaningful form is given to the results of the analysis.

Using the methodology of system analysis allowed to development a principal management model of transport flows and objects of infrastructure [15; 16].

5. Conclusions

Conceptual elements of the methodology of intelligent management are presented in this scholarly paper. The described methodological and conceptual approaches to the intelligent management of transport flows and objects of infrastructure allow developing the main stages of the implementation of intelligent management in the enterprise.

Developed scheme of modeling an intelligent system in a transport enterprise allows creating a generalized model of intelligent management, and has determined the direction of future research. This determines the direction of future research.

Intelligent management is an interesting field of application of theoretical cybernetics in modern information systems. Mathematical methods that are used in problems of intelligent management are determined, basically, by the nature of the object of control and the environment – their features and complexity. Intellectual properties are essential to the functioning of intelligent transport systems. Their functioning takes place in the conditions of incompleteness, inaccuracy and uncertainty of data, as well as the multi-criterion of the decisions made, which complicates the decision-making process. Therefore, intelligent transport systems should include solution algorithms based on the use of artificial intelligence.

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